Infrastructures impacts assessment

Deliverable 4

Status: Public

TRANSECON

Contract No GMA1-2000-27049

Date: 21. 03. 2003

PROJECT FUNDED BY
THE EUROPEAN COMMISSION
UNDER THE COMPETITIVE AND
SUSTAINABLE GROWTH PROGRAMME
OF THE 5TH FRAMEWORK PROGRAMME

The TRANSECON consortium

Co-ordinator:

- Institute for Transport Studies – University for Bodenkultur (ITS-BOKU), Vienna (A).

Partners:

- Steinbeis Transfer Centre Applied System Analysis (STASA), Stuttgart, (D).
- Stratec (STRATEC), Brussels (B).
- PRI.DOS – Planning Bureau, Bratislava – V. (PRIDOS), Bratislava, (SK).
- Synergo (SYNERGO), Zuerich (CH).
- Transportation Planning and Traffic Engineering Section, Delft University of Technology (TUD), Delft (NL)
- University THESSALY (UTH), Volos (EL)
- Universidad Politecnica de Madrid – Transport Department (UPM), Madrid (E).
- Viatek (VIATEK), Espoo (FIN).
- Faber Maunsell (FM), Manchester (UK).
- Laboratoire d'Economie des Transports, Lyon (F),
Université Lumière Lyon 2 (LET ULL2)
- Laboratoire d'Economie des Transports,
Centre National de la Recherche Scientifique (LET-CNRS)
- University of Newcastle upon Tyne, Transport Operations Research Group (UNEW), Newcastle (UK).
- Consorcio Regional de Transportes de Madrid (CRTM), Madrid (E).
- ISIS (ISIS), Lyon (F).
- University Linz, Department of Economics (ULINZ), Linz, (A).

The Commission of the European Commission has financed 88 % of this research work within the Fifth Framework Programme

Infrastructures impacts assessment

DOCUMENT PRODUCED BY

Responsible Organisation	Author(s)
LET	Patrick Bonnel Charles Raux Romain Petiot Jean-Michel Cusset

IN COOPERATION WITH

BOKU-ITS CRTM ISIS FM PRIDOS STASA STRATEC SYNERGO TUD UNEW UPM UTH VIATEK	

APPROVED BY

Peer Review 1

UPM	Andres Monzon

Peer Review 2

UNEW	John Nelson

Project Co-ordinator

ITS-BOKU	Gerd Sammer Roman Klementschitz Oliver Roider

Technical Officer (EC)

DG-TREN	Michael Janik

TABLE OF CONTENTS

DELIVERABLE 4A - APPENDIX

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

The ***TranSEcon*** project addresses “task 2.1.2/4 cluster on socio-economic impacts of transport investments and policies and network effects” -frame of studies in the key action of “sustainable mobility and intermodality” and in particular “subtask 3: urban transport and local socio-economic development” (accompanying measures project).

Urban transport policies and investments are implemented on the basis of urban transport planning and management and therefore their evaluation usually is linked to performance in terms of transport operations (e.g. travel-speed, travel-safety). However, urban transport policies and investments may have wider socio-economic impacts and effects not only along the corridor or within the areas that are designed to serve, but throughout the city-region and through time. Therefore it is necessary to carry out research in evaluating these socio-economic impacts and effects stemming from urban transport policies and investments.

The main expected technical achievement of this research is to provide documentary evidence regarding the social and economic long-term impacts and effects of urban transport investments and policies (so called “indirect effects and impacts”), in order to inform city authorities in their transport and related policy development and infrastructure planning, as well as to support relevant EU policies.

1.2 Project Objective

The ***TranSEcon*** research project aims to provide a qualitative and quantitative evidence regarding the existence of the direct and indirect effects and impacts of transport infrastructure investments in 13 European cities.

The long term effects of implemented large scale infrastructure investments of all types of mode are to be analysed using existing data-bases together with stakeholder interviews in the 13 European case studies. The selected case studies cover a good range of city and intervention types (in terms of geographical distribution, city size, transport policies and investments). The research partnership involves 16 organisations (6 universities, 2 research centres, 7 consultancies) in 9 EU member states, an EEA country and an Accession country.

The methodology is driven from a multi-disciplinary perspective requiring expertise in related fields such as: urban and regional land use planning and sustainable development planning, urban re-generation and renewal design, implementation and management, sociology, macro-economics, development economics, labour economics, political science, decision making process, organisation science and institutional development. Thus the project approach is not to concentrate on the normal transport-related socio-economic impacts (e.g. modal split changes, accessibility improvements, time savings, vehicle operating cost changes, environmental and safety benefits, revenues and financial concerns).

The project work-plan involves 12 inter-related work packages, which address operational requirements (such as database development, dissemination, project co-ordination) as well as thematic impact assessment topics (such as policy, infrastructure, employment, urban re-generation, etc) see Figure 1-1.

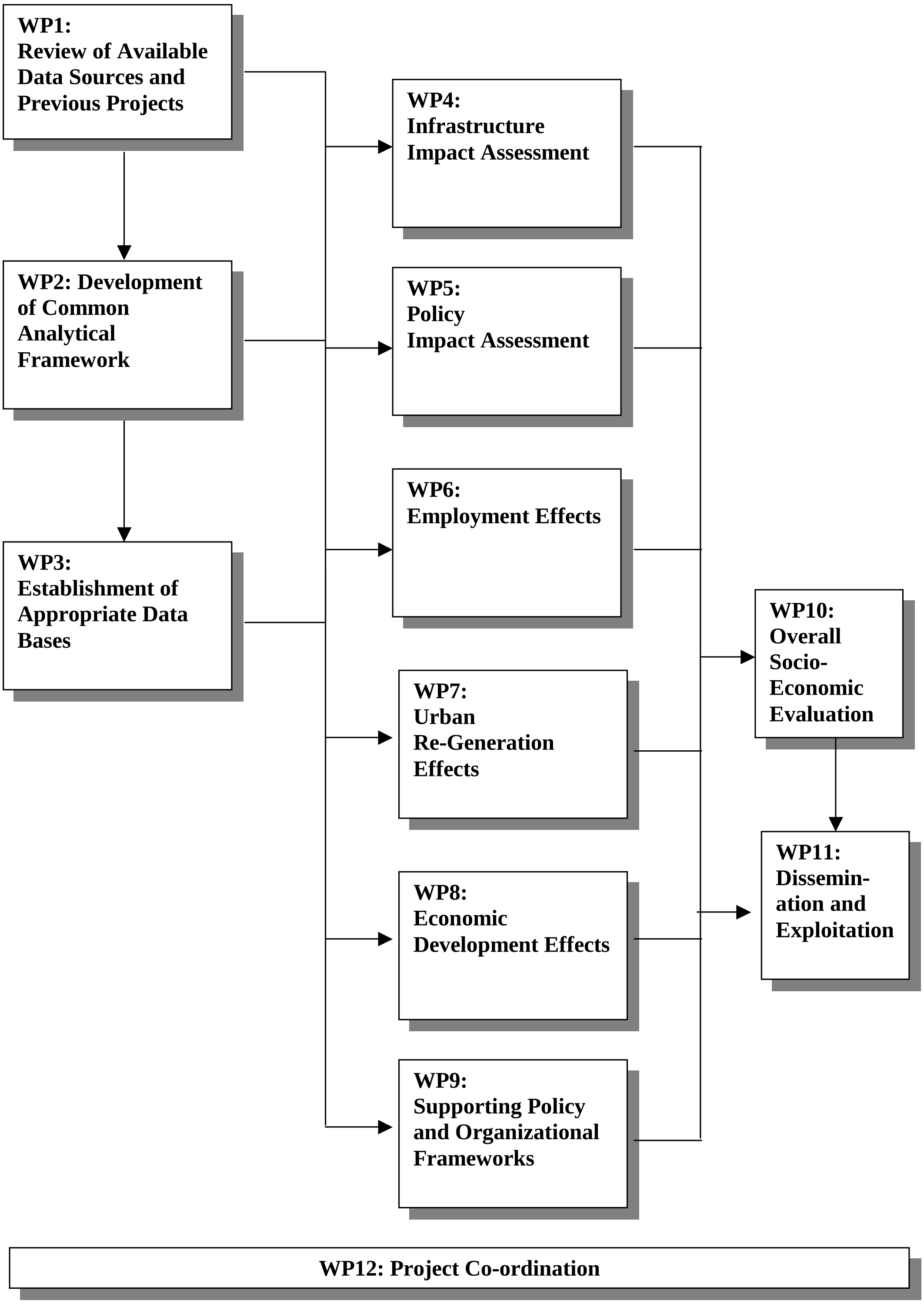

Figure 1-1: Work Package flow chart of ***TranSEcon***

Work package 4 works complements policy and other socio-economic impacts addressed in the other work packages 5 to 9 (Figure 1-1).

Work package 4 work analyses each case study individually following the general methodology defined in work package 2 (the relevant sections of Deliverable 2 for WP4 are presented in chapter 2). Individuals case study analyses are presented in appendix 2 to 14. The core of this report is a comparative analysis of all the elements of the transport system.

The objective of the work package is to produce qualitative analysis of the evolution of the transport system after important infrastructure investment project, and also to produce quantitative indicators. These indicators will be developed for use in work package 10 “Overall socio-economic evaluation”.

1.3 Content of the report

Report is organised as follows:

- chapter 2: presentation of the general methodology for impact assessment within ***TranSEcon*** project. The basis of this has been described in Deliverable 2 and the relevant sections for work package 4 from that deliverable are exactly reproduced here;
- chapter 3: presentation of the general framework of work package 4. In this chapter the application of the general methodology developed for work package 4 is described. The grid of indicators is first described and then data production and collection is commented;
- chapter 4: presentation of the case studies;
- chapter 5: description and impact on public transport and private transport supply system. Here some indicators are described to quantify both public and private transport supply. The impact on investment, operating costs and transport related revenues is then analysised;
- chapter 6: analysis of the impact on demand of the case studies project in terms of mobility, passenger*kilometre and time savings;
- chapter 7: is dedicated to results concerning transport environment and safety impact analysis.

2 GENERAL METHODOLOGY FOR IMPACT ASSESSMENT WITHIN TRANSECON PROJECT

The general methodology for impact assessment within ***TranSEcon*** project has been defined in work package 2 and described in deliverable 2 "Common analytical framework". This chapter reproduces this general framework exactly. Chapter 3 describes the application of this framework.

2.1 Analytical framework[1]

The overall analytical framework of the ***TranSEcon*** project is represented Figure 2-1. This takes into account the key issues discussed in the previous section.

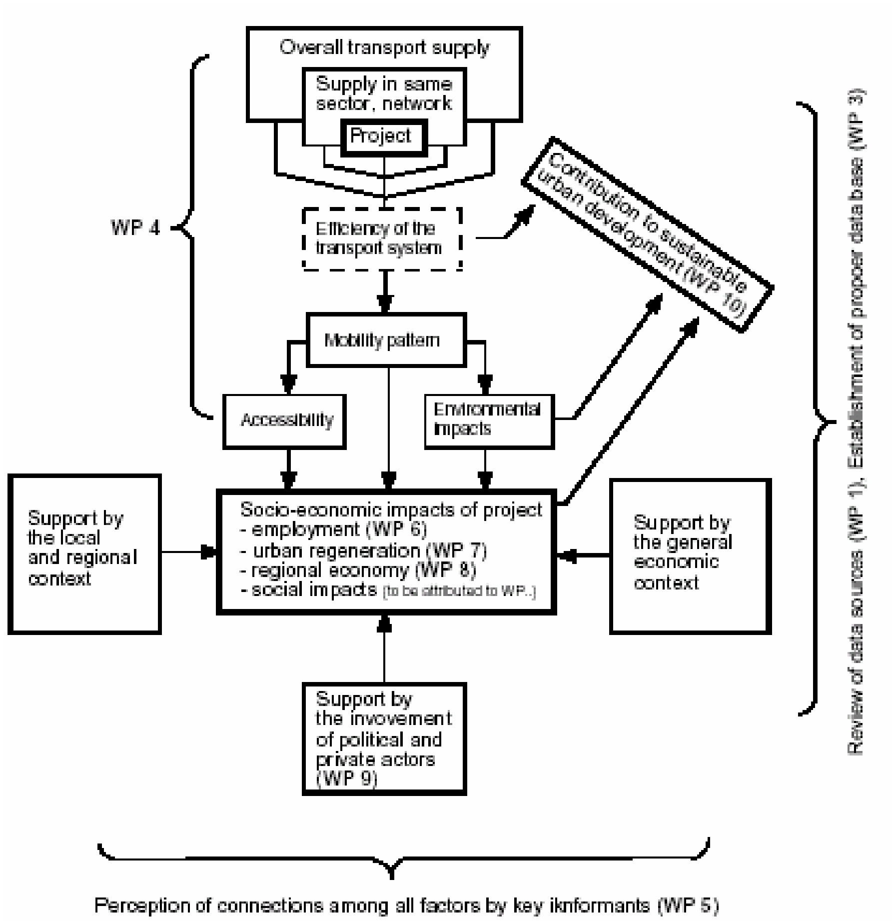

Figure 2-1: Analytical framework for the ***TranSEcon*** project

The analysis starts with the identification of the projects (large scale infrastructure investment), as part of a network of the same type and in the context of the overall transport system in the urban region. The analysis ends with the assessment of the

1 Section 2.3 of Deliverable 2

project's contribution to sustainable urban development (top right part of the diagram).

Within the chain of effects that leads from the start to the end there will be some effects that are relevant for the final assessment, such as:

- the efficiency-increase of the transport system, induced by the infrastructure investment;
- the changes in environmental quality, as a result of the effects of the infrastructure investment on the mobility pattern;
- the socio-economic impacts of the project (as the core part of the assessment and the ***TranSEcon*** project), that are induced by changes in the accessibility of the region and its territorial subdivisions, by changes in the environmental quality, and in addition by the above mentioned exogenous and endogenous contextual inputs.

All this together allows for the triple evaluation under economic, environmental and social criteria that is characteristic of the sustainability principle. For each element of the analysis suitable indicators need to be developed and, for their interaction, significant lines of argument must be developed.

2.2 Categorisation of effects with regard to time[2]

The life-cycle of a transport infrastructure investment can be classified in the following phases (see also Figure 2-2):

- the planning, evaluation and design-phase; during that phases the political decision is made;
- the construction phase;
- the operation phase.

The planning and evaluation phase of a potential infrastructure investment normally provides an estimation of its forecasted quantitative and qualitative effects. This helps the decision makers to start or to reject the project. The estimation consists normally of cost benefit calculations and descriptions of other societal benefits. In order to make a positive decision to invest (the decision to start the transport infrastructure investment) more positive than negative effects and expectations need to exist. The investment must be seen to be beneficial for the city and it must be seen to support the transport and mobility policy of society.

The direct effects and impacts of the construction phase can be negative for the use of (public) transport system, if the construction work hinders the use of public transport (lack of service, poor replacement services, poor temporary connections etc.). The effects can be seen, e.g. in passenger statistics and in general opinions collected (e. g. complaints) concerning the construction phase. The construction phase can change the modal split at least temporarily if the former users of public transport shift to private car use (more private car users in the area where the

[2] section 2.4 of deliverable 2

construction work is done). From a marketing and public acceptability point of view, there is a need for minimising the negative impacts of any new transport system during the construction phase.

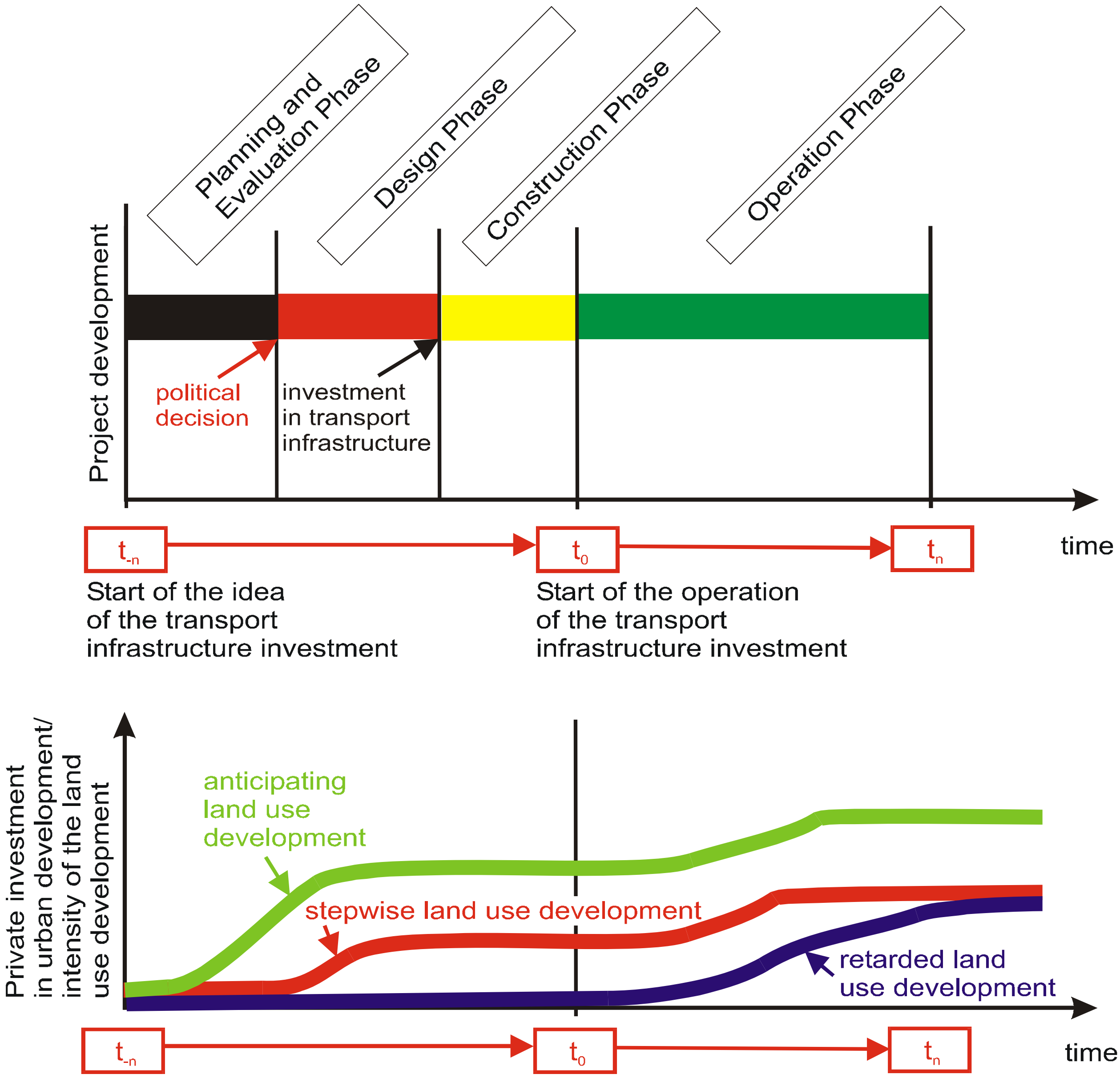

Figure 2-2: Infrastructure investment development and land use development

Because ***TranSEcon*** is focused on the investigation of socio-economic effects and impacts, the influence of the different phases on these effects have to be particularly considered. Transport policy measures, especially infrastructure investments, can have an effect on real estate development at different phases of the infrastructure investment life cycle (see

Figure 2-2). Decisions for private investments can occur long before a political decision is taken on the infrastructure investment, during construction or after start of operation. Compared with the phase the infrastructure is ready for operation, the socio-economic impacts could occur earlier and/or later. By probably excluding some important impacts, this time shifts can have a great influence on the result of the evaluation.

The reasons for such anticipating, stepwise or retarded private reaction on infrastructure investment may be that not all real estate developers assess investment risks in the same way, and that local or general economic contexts of private investment show certain cycles as well. It is common knowledge that infrastructure investment cycles and private investment cycles often do not have the same rhythm. Monitoring of socio-economic effects of transport infrastructure and policy measurers must take account of such interference.

As a conclusion for the ***TranSEcon*** project it is necessary to distinguish two classes of impacts and effects:

- impacts and effects, which occur during the planning, evaluation, design and construction phase;
- impacts and effects which occur during the operation phase of the infrastructure investment;

2.3 Definition and relevance of effects and impacts[3]

The ***TranSEcon*** project is being carried out simultaneously with two other projects: TIPMAC and IASON. These projects are clustered with ***TranSEcon***. Therefore definitions in all three projects should be harmonized, although it must be stated, that each project has different demands on definitions caused by different objectives. At least it must be ensured, that definitions used are not inconsistent.

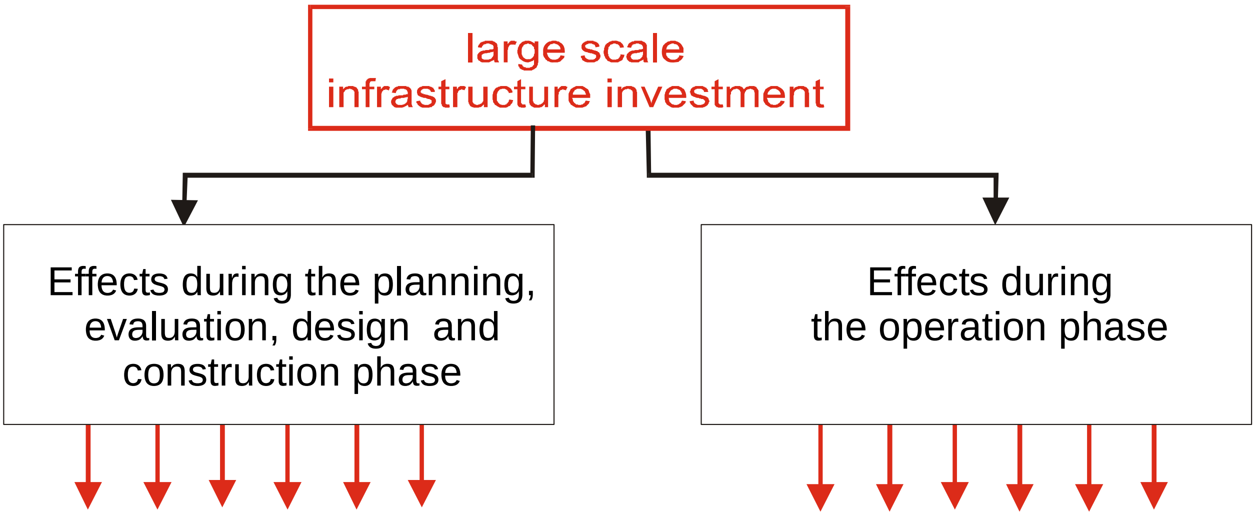

Figure 2-3: Classification of effects

3 section 2.5 of Deliverable 2

An additional distinction of relevant effects of each measure has to be defined and investigated (see Figure 2-3):

- effects during the planning, evaluation, design and construction phase;
- effects during operation phase of the invested infrastructure investment.

2.3.1 Planning, evaluation, design and construction phase

In Figure 2-4 the different types of effects are presented, which occur during the infrastructure development phases:

Direct effects
These direct effects are related to transport users, operators, neighbours who are directly affected by the planning, evaluation, design and construction work of the transport investment. These effects can be measured in changes of route choice, destination choice, travel-costs, travel-time etc. of the effected transport users or changes in revenue/costs for pt-operators, noise and gas emissions caused by the construction work or changes in the transport supply for users. These effects have a relative short time impact and mainly occur during the construction phase. They are not very relevant.

Direct network effects
The direct network effects occur within the transport system and are caused by changes in transport behaviour of the direct effected users, operators, neighbours or by transport caused by construction work transferred by network flows to other users of the network, who are not themselves directly affected by the construction work of the infrastructure investment. These effects can cause changes in route choice, destination choice, travel costs, noise and gas emissions etc. of these not directly affected users. These effects have a relative short time impact and mainly occur during the construction phase, therefore they are not very relevant.

Indirect effects (third-party effects, socio-economic effects)
These effects are distinguished from the direct effects because they are transmitted throughout the transport market outside of the transport system. These effects are caused by the planning, evaluation, design and construction work but they occur in an other market system as labour-market (e. g. the consultants who are involved in the design phase), product market (e. g. production of public transport vehicles) etc. These effects are very relevant for the ***TranSEcon*** project, but they have a relative short time impact and mainly occur during the design and construction phase.

Indirect network effects
These effects are caused by the changes in the indirect or third party effects and occur in the transport system. Changes in the employment and product market causes changes in the transport demand. This transport demand produces changes in the traffic flows, which are generated through other markets. These indirect network effects have a relative short time impact and are not very intensive. Therefore they are not very relevant.

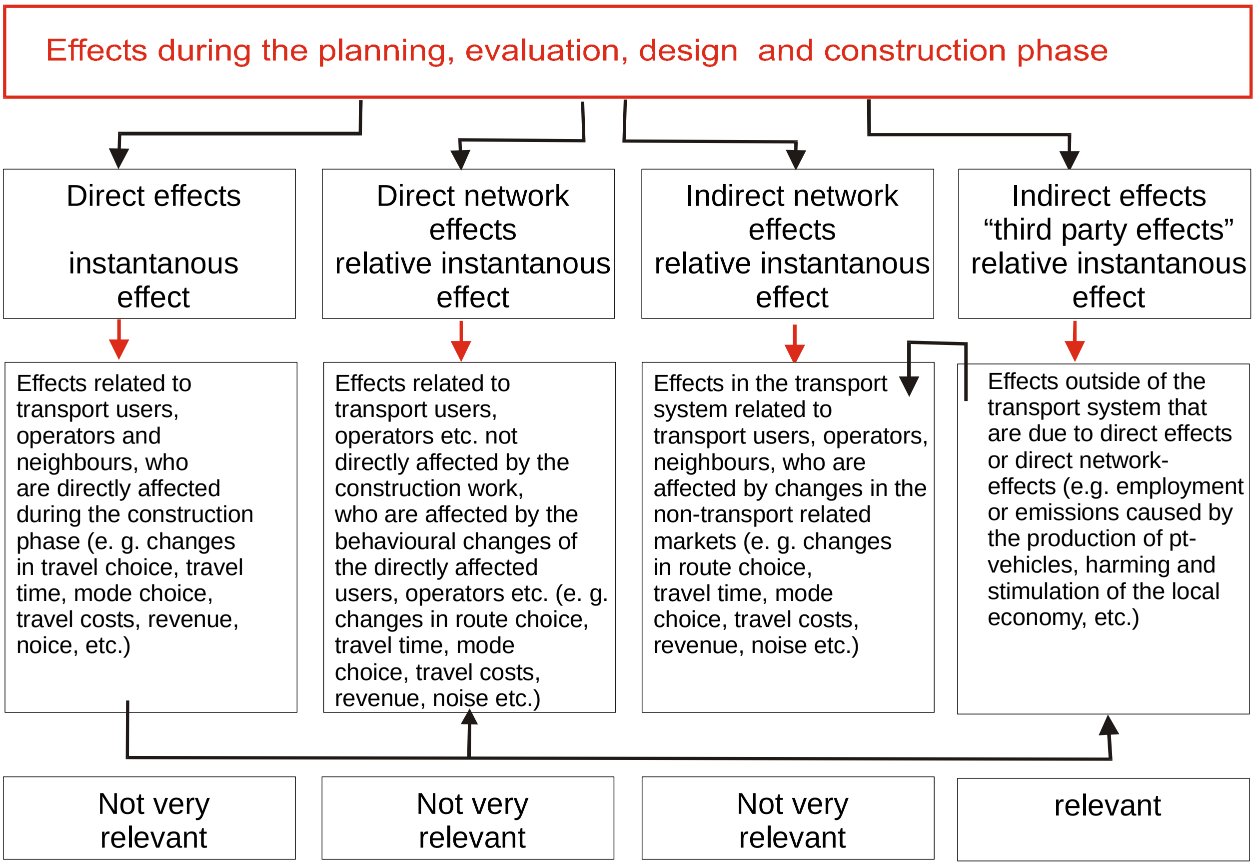

Figure 2-4: Classification of effects in the planning, evaluation, design and construction phase

2.3.2 Operation phase

The effects during the operation phase are classified in the following way (see also Figure 2-5):

Direct effects

The effects are related to transport users, operators, neighbours, who are directly affected by the transport investment and policies. These effects can occur as changes in the transport behaviour (route-choice, travel-time, destination-choice, travel costs, etc.) but also as changes for the operator or neighbours of the infrastructure investment (changes in operation costs, investment costs, gas emissions, noise, etc.).

Direct network effects

The direct network effects occur within the transport system. They are related to not directly affected transport users, operators or other concerned people. These persons are affected by the behavioural changes of directly effected transport users, operators or neighbours, what causes network effects e. g. in transport flow. This could lead to changes in route choice, destination choice, travel costs, noise and gas emissions etc. of these not directly affected users as well.

Indirect effects (third-party effects, socio-economic effects)
These effects are long term effects which occur in other markets than the transport system. They are caused by the changes in accessibility and other effects transmitted throughout the transport network and are leading to changes in the labour market, product market, health and environmental situation, etc.

Indirect network effects
These effects are caused by the changes in the indirect or third party effects and occur in the transport system. Changes in the labour market, product market and attractiveness of the city are influencing the transport demand. This transport demand produces changes in the traffic flows, which are generated through these other markets.

To conclude, effects during the operation phase show how the new infrastructure investment is adapted by the society; what kind of effect it has on land use, modal split, other services and development in the area, and how well it completes the transport system as a whole etc. ***TranSEcon*** will mainly focus on indirect effects (third party effects). But direct effects, direct network effects and indirect network effects will also be considered (work package 4).

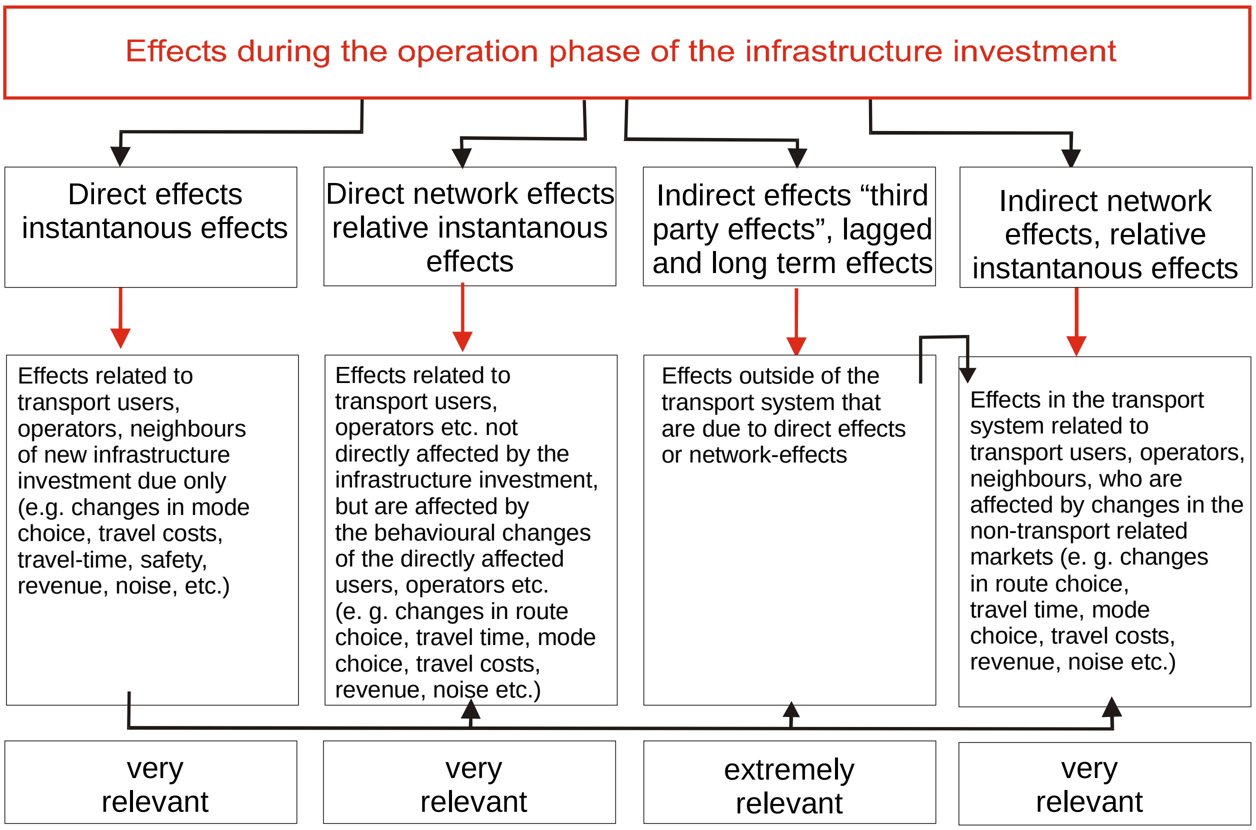

Figure 2-5: Classification of effects in the operation phase”

2.3.3 Indirect effects

The indirect effects are the main focus of the ***TranSEcon*** project. Figure 2-6 gives an overview, which type of the indirect effect will be investigated and which work package is responsible for.

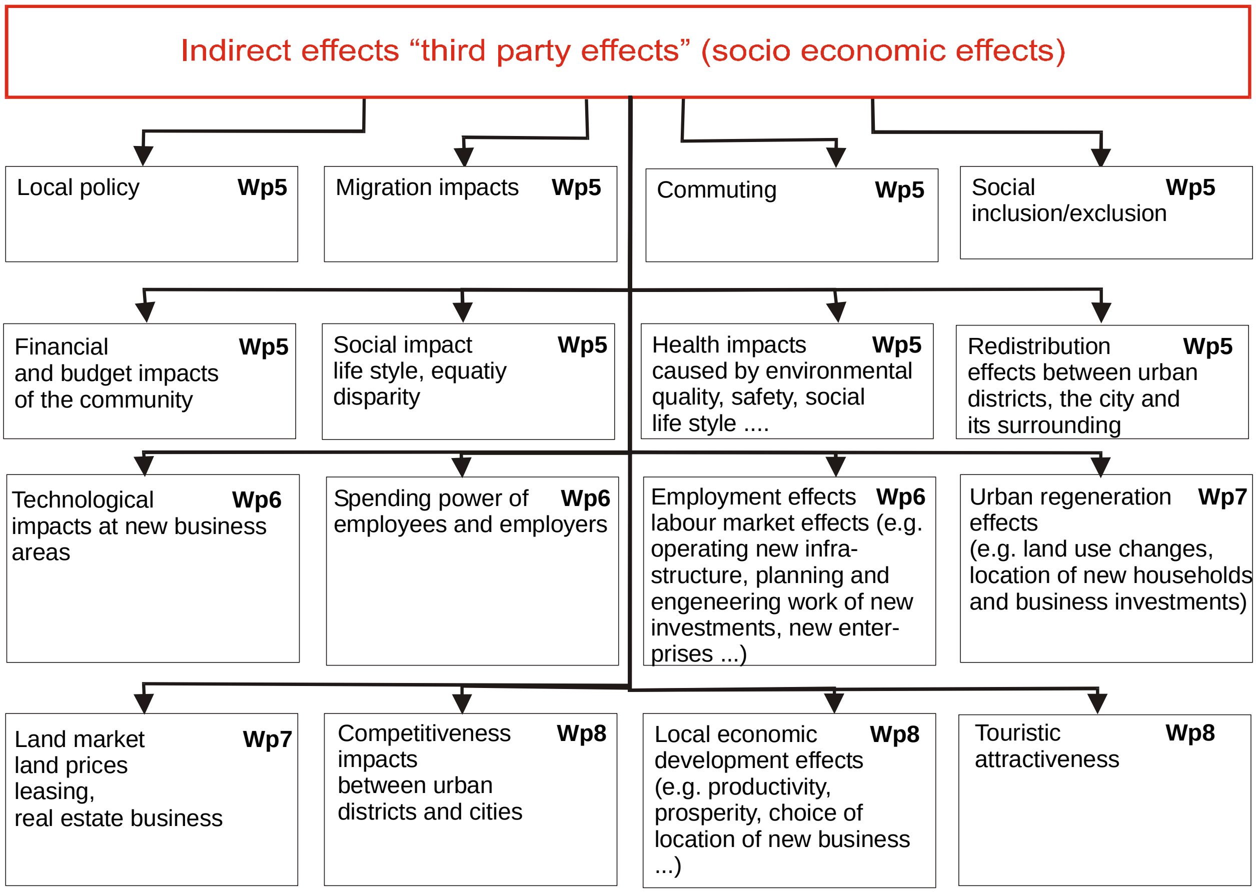

Figure 2-6: Overview of the indirect effects and the relevant work package

2.4 Spatial distribution of impacts and effects[4]

Changes in the transport infrastructure in a specific area can have a positive or negative impact in other parts of an urban region. It is possible that positive impacts in one urban area is causing negative impacts in another urban area, which does not benefit of an improvement in transport infrastructure (so called **local impacts**). Possible types of these effects could be direct and indirect network effects or indirect effects (see also section 2.3). In addition transport infrastructure may have a positive or negative impact on the city region as whole. It is important to find out how the competitiveness of the city is increased/decreased compared to those of others (so called **inter-regional impacts**) This type of effect is considered as an indirect or socio-economic effect.

4 section 2.6 of Deliverable 2

Investigating direct effects the study area is ideally a corridor along the infrastructure investment including some districts, suburbs or subdivisions of the city. Direct and indirect network effects can occur in the whole transport system itself. In some extreme cases, intercity relations are affected as well. Usually for urban infrastructure investments it is sufficient to consider the transport network (all modes) of the conurbation area or the corridor of the case study to determine the direct and indirect network effects.
A further point is that not only the transport related network indirect effects should be considered, but also the other markets in the area (e. g. labour- or product market)

Thus, it is very important for ***TranSEcon*** to take into account the spatial distribution of the effects and impacts, in dependency and the type of effect. This will be done in work package 4 to work package 9. It is one of the main objectives of ***TranSEcon*** to get results about the mechanism of the spatial distribution of the indirect effects.

2.5 Definition of scenarios[5]

Types of measures:
On the basis of the survey undertaken in work package 1 of ***TranSEcon*** to establish the type of measures and data availability for each of the case studies, two types of broad measures can be classified:

- infrastructure investments, typically improving the public transport systems such as metro and light rail, bus priorities, suburban rail, intermodality, including park & ride facilities, establishing a bicycle network and pedestrian zones, but sometimes also an extension of the urban road network and road traffic capacity improvements;
- policy measures by traffic regulation and/or management (such as access control, parking control, staggered working hours, car pooling, traffic calming, etc.), or pricing (such as public transport fare subsidies and integrated ticketing including multiple or season passes, parking pricing, special charges, etc.), or promotion of intermodality between transport modes including park & ride, bike & ride facilities. These measures can be seen as accompanying measures to the infrastructure investment.

Types of scenarios:
For assessment purposes, at least three different scenarios have to be defined in ***TranSEcon***:

[5] section 2.7 of Deliverable 2

- scenario of existing situation before the implementation of the infrastructure investment. This scenario describes a real life situation (scenario 0 at t-n);
- scenario with the implementation of the infrastructure investment. This scenario describes a real life situation (scenario 1 at tn);
- scenario without implementation of the infrastructure investment (in literature “do-nothing scenario” or “do minimum scenario”). This scenario is fictitious, no real life data are existing (reference scenario at t_n).

The impact analysis is based on comparing scenarios with or without the infrastructure investment. Unlike the situation “before implementation” the “reference scenario” will include possible developments in the case study area over the time period investigated. In the reference scenario a reference district in the case study city without investments in extending the transport infrastructure can be used to determine possible developments (especially for the determination of the indirect effects). A second possibility determining these effects and impacts of the reference scenario is a modelling procedure (especially to determine the direct and indirect network effects). The reference scenario can include alternative transport infrastructure investments in other areas in the same community, transport infrastructure investments in other modes in the same community, investments in other sectors in the same community (e.g. housing), transport infrastructure investments in other communities (same or other mode), no investment at all and tax reduction or reducing of the public household deficit or simply “do nothing” scenario. That means, that the reference scenario can consist of a big variety of different measures with a high variety of the spatial and social distribution of effects and impacts. For the ***TranSEcon*** case studies it is not possible to get the information: In which way the financial resources would have been invested if the transport infrastructure measure would not have been realised? Therefore the reference scenario could be assumed as no alternative investments affects the development of the case study area.

To conclude, in each case studies following scenarios are to be defined:

- the scenario existing situation before construction;
- the reference scenario without implementation of the infrastructure investment; an alternative investment would not have affected the case study area;
- the scenario with implementation of infrastructure investment.

The difference in time between year t_0 and t_1 is important. ***TranSEcon*** will be studying infrastructure projects as a rule that have been in existence for at least 10 years time of operation between t_0 and t_1.”

In the following these three scenarios are called:

- before scenario (some times the abbreviation Before is used);
- reference scenario (some times we use the abbreviation RS is used);
- scenario with (some times we use the abbreviation with is used).

Next chapter 3 described how this general framework is applied for work package 4.

3 GENERAL FRAMEWORK OF WP4

3.1 Application of the general framework to work package 4

In this paragraph, the application of the main elements of the general framework for ***TranSEcon*** work to work package 4 is defined.

Effects during the planning, evaluation, design and construction phase are excluded from work package 4. This kind of effect on transport systems are mainly short time effects which are not fully considered in ***TranSEcon***.

The analysis concentrates on effects which occur during operation phase. It can be seen from the classification of effects (Figure 2-5), that the main concern are the direct effects, direct network effects and indirect effects which impact on transport systems. Indirect network effects mainly concern urban system other than transport systems. These indirect network effects are not considered as they are the core of work packages 5 to 9.

Understand the effects considered in work package 4 requires discussion of time horizon (section 3.1.1), zoning (section 3.1.2) and reference scenario (section 3.1.3).

3.1.1 Time scale

TranSEcon is mainly concerned with long term effects. Traditionally this time horizon is thought more relevant for the quantification of effects on different urban sectors other than transport (like housing market, labour market, economic effect…), in contrast to effects inside transport system where main effects are observed at short term. After short term transport effects are generally decreasing. For work package 4, three time horizons are defined:

- Short time (2-4 years after the investment);
- Medium time (4-6 years after the investment;
- Long time (about 10 years after the investment).

Of course when available, data for the situation before the investment is added. Time horizon for each case studies is given in sections 11.1.3 to 11.13.3.

3.1.2 Zoning of case study

The analysis of the impacts for all case studies should allow us to assess the impacts on the project area (direct effects). We therefore define for all case study the area of the project. We call this zone “Zproject”. We define this zone as the catchment area of the investment to be assessed. This catchment area is defined as a circular zone around each station of the public transport investment, with a diameter comprised between 500 metres and 2 kilometres which depend on the nature of the public transport investment.

Next zone is directly affected by the investment. In general it is in this zone that the greater effects (except in Zproject) can be seen at the level of the conurbation. It's the zone of the direct effect network. In this report we call this zone "Z1 zone".

The last zone corresponds to a sector of the conurbation where the effects are generally less important, but still non negligible. It's the zone where main indirect network effects will be found. This zone is defined as "Z2 zone". In some case studies, this zone will be divided into two zones Z2a and Z2b. This distinction allows to hierarchy Z2 zone information in relation with the importance of the effect (more important in Z2a than in Z2b).

For two case studies a "Z3 zone" has been defined. It's a control zone where the investment to be assessed has no impact at all, and where there was no important investment in transport sector. This zone is used for the two case studies to calculate the effect of the investment from a comparison of indicators evolution in Zproject, Z1 and Z2 zones on one hand and Z3 zone on the other hand.

In order to harmonise the definition of Z1 and Z2 between case studies, there are two different cases depending on the nature of the public transport investment. The first case corresponds to an investment mainly dedicated to improve public transport system in the centre of the conurbation (Figure 3-1). The second one corresponds to an investment which improve public transport relation between suburb and centre of the conurbation or between suburbs (Figure 3-2).

Case 1. The project concerns the inner city

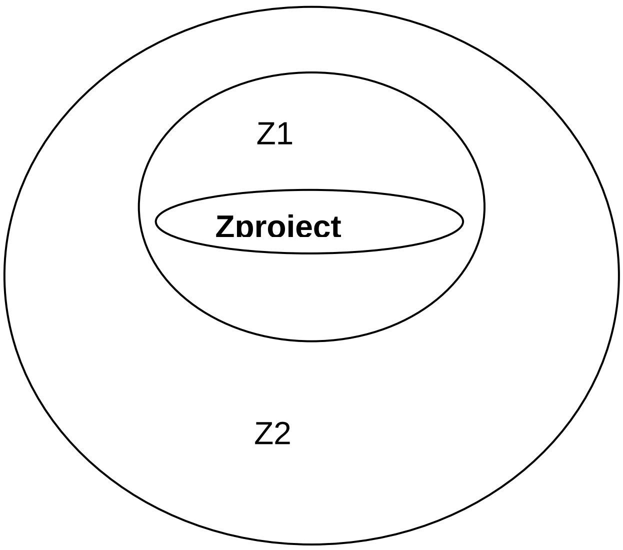

Figure 3-1: Zoning for case study with public transport investment in the centre of the conurbation

Case 2. The project concerns the suburbs

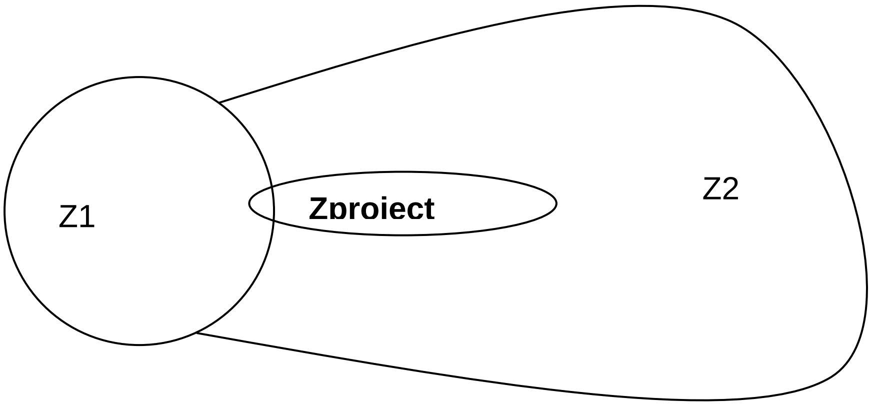

Figure 3-2: Zoning for case study with public transport investment in the suburbs of the conurbation

For the comparative analysis a distinction is made between this two different zoning systems.

For each case study a definition of the three different zones (Zproject, Z1 and Z2) is provided with a map presenting the zoning system. Data on population, employment and density is also given so as to take into account the context of each conurbation (sections 11.1.4 to 11.13.4).

3.1.3 Definition of the reference scenario

The absence of a common definition for all case studies of a reference scenario in deliverable 2 for work packages 4 to 9 is a crucial problem for work package 4. Each case study has to define its own definition guided by the definitions which have been proposed in deliverable 2 (section 2.5). But if the situation is relatively clear regarding the investment which is assessed (each case study consider a situation where the investment is not realised except Bratislava and Zurich case studies who use a control area (Z3 zone)), it is not so clear which other components of transport policy such as other investments in public transport than the investment considered in the case study and road infrastructure and parking investment or management should be considered.

Furthermore, the absence of transport models in several conurbations does not permit the computation of the effect of a reference scenario where it is assumed the investment is not realised. Even for conurbation where a model is available, the structure of the model does not always permit to produce data for all modes of transport and for parking nor financial data for transport system.

Therefore, the definition of the reference scenario which has been chosen by each case study partner is given in sections 11.1.5 to 11.13.5 and data collection process in sections 11.1.6 to 11.13.6.

3.2 Presentation of the indicators grid

The assessment of the impacts of urban transport infrastructures leads to quantifying the role of new transport supply on the urban transport system. New indicators which contribute to characterise the urban transport need to be defined.

These quantitative indicators should characterise the transport system and be suitable in use in work package 10 for the overall socio-economic evaluation. Both public transport and private transport are considered as well as both the supply and the demand sides. Lastly the effects of transport production and use on non users will need to be taken into account.

In order to respond to the list of tasks which have been defined in work package 4 description inside the ***TranSEcon*** project, indicators are organised in four groups.

3.2.1 Structure of the list of indicators

The first group of indictors assess the extent to which the project modifies the urban transport supply. The comparison of the public transport supply between the two scenarios measures the public transport performances gap due to the project. It would provide an assessment of the part of the investment on supply variation. Therefore, this group of indicators would provide the principal arguments to conclude the actual effect of the new project on the public transport supply.

The second group of indicators aims to quantify the effect of the project on transport demand. These indicators should quantify the evolution of transport demand and trip behaviour. It therefore allows a quantification of the role of the new project on modal split.

The third group of indicators deals with the impact of the new project on time savings. The aim here is to assess the extent to which the investment modifies the time spent on transport.

The fourth group deals with the impact of the new project on the transport environment, mainly emissions and safety. The objective is to isolate the part played by the new supply in the variation of the level of environmental externalities.

Therefore, the indicators are organised in 4 groups:

- urban transport system and supply;
- mobility and trip behaviour;
- time savings;
- transport environment.

3.2.2 Tables of Indicators

3.2.2.1 Urban transport system: supply

Both public transport and private transport systems are considered.

The public transport system: network and operator
The public transport system assessment needs to ascertain the gap in the supply performance characteristics between the two scenarios. The supply level is first defined, the effect of the investment on financial characteristic of the public transport network (cost operation, operation revenue, investment, contribution of the public transport authority).

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Characteristics of the network	**Capacity in number of standing and seating places.km**	Z1+Z2	Short term	Appraisal of the variation in the public transport system quantitative supply. In what measure has the project an impact on the overall public transport supply?	no
			Medium term		
			Long term		
		Zproject	Short term		
			Medium term		
			Long term		
Financial characteristics	**Annual fare revenue**	Z1+Z2	Short term	This indicator allows an assessment of the impact of the new investment on the overall public transport revenue.	yes
			Medium term		
			Long term		
		Zproject	Short term		
			Medium term		
			Long term		

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Financial characteristics	**Annual operation costs**	Z1+Z2	Short term	This indicator allows the assessment of the impact of the new investment on the overall public transport operation costs.	yes
			Medium term		
			Long term		
		Zproject	Short term		
			Medium term		
			Long term		
	Total investment expenditures for the project	Zproject	Short term	This indicator characterises the financial input of the project	yes
			Medium term		
			Long term		
	Annual investment (other than for the project)	Z1+Z2	Short term	This indicator allows a comparison of the financial weight of the new project investment in overall public transport investment.	yes
			Medium term		
			Long term		
	Annual contribution of the transport authority to public transport	Z1+Z2	Short term	This indicator allows the assessment of the weight of the new investment in terms of its dependence to the financial public contribution.	yes
			Medium term		
			Long term		

Private transport supply
The indicators characterises private transport supply: car ownership, road supply and parking facilities in the two scenarios.

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Car ownership	**Number of passenger cars per 1000 inhabitants**	Z1	Short term	This indicator allow the assessment of the impact of the new project on the car ownership	No
			Medium term		
			Long term		
		Z2	Short term		
			Medium term		
			Long term		
Road network	**Average speed of trips by car**	Z1-Z1	Short term	This indicator allows the assessment of whether the new project has an impact on the performance level of road supply	Yes
			Medium term		
			Long term		
		Z1-Z2	Short term		
			Medium term		
			Long term		
		Z2-Z2	Short term		
			Medium term		
			Long term		

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Road network	**Length of the expressways (unrestricted roads)**	Z1+Z2	Short term	These context indicators are to assess if road supply has increased compared to the increase in public transport supply. They give an idea of road transport policy in the case study in comparison with the public transport policy (including the project).	No
			Medium term		
			Long term		
	Complete circular road with expressway	Z1+Z2	Short term		No
			Medium term		
			Long term		
	Road with traffic calming measures	Z1	Short term		No
			Medium term		
			Long term		
		Z2	Short term		
			Medium term		
			Long term		
	Investment expenditures for increasing urban road network	Z1+Z2	Short term		Yes
			Medium term		
			Long term		
	Average car fuel price	Z1+Z2	Short term	Context indicator to assess the level of road transport cost.	No
			Medium term		
			Long term		

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Parking facilities	**Capacity of public (off-street) car parks**	Z1	Short term	Parking supply indicators to indicate scope of accompanying measures to the project and to evaluate the impact of the project on the parking policy (restructuration, etc.)	No
			Medium term		
			Long term		
	On-street public parking slots	Z1	Short term		No
			Medium term		
			Long term		
	Private supply	Z1	Short term		No
			Medium term		
			Long term		
	Average on-street parking occupation rate	Z1	Short term	The project may have an impact on the parking behaviour. These indicators provide an assessment of the impact of the project on the parking use.	No
			Medium term		
			Long term		
	On-street parking turnover rate	Z1	Short term		No
			Medium term		
			Long term		
	Number of parking slots of park and ride facilities	Zproject / Z1 / Z2	Short term	Context indicators of the parking policy.	No
			Medium term		
			Long term		
	Off-street fee revenue	Z1	Short term		Yes if available
			Medium term		
			Long term		
	On-street parking fee revenue	Z1	Short term		Yes if available
			Medium term		
			Long term		

3.2.2.2 Mobility and trip behaviour

The aim is to assess the impact of the public transport infrastructure in term of urban mobility. The indicators show to what extent the new public transport supply modifies the trip behaviour (in terms of public transport and car use and modal shift to public transport). This impact is quantified both in terms of number of trips and passenger kilometre so as to calculate total time savings or emissions.

Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Number of public transport trips (including the project area)	Z1-Z1; Z1-Z2; Z2-Z2; Zproject	Short term Medium term Long term	A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study.	Yes
Number of public transport trips on the project only	Zproject	Short term Medium term Long term		Yes
Passenger-km (including the project area)	Z1-Z1; Z1-Z2; Z2-Z2; Zproject	Short term Medium term Long term		Yes
Passenger-km on the project area	Zproject	Short term Medium term Long term		Yes
Number of car trips	Z1-Z1; Z1-Z2; Z2-Z2	Short term Medium term Long term		Yes
Car-km	Z1-Z1; Z1-Z2; Z2-Z2	Short term Medium term Long term		Yes
Modal shift to public transport	Z1-Z1; Z1-Z2; Z2-Z2; Zproject	Short term Medium term Long term		No

3.2.2.3 Time savings

Time savings **are an important issue in the assessment of** the effect of the **transport** investment.

Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Average trip travel time on the public transport (bicycles for Delft) network	Z1-Z1; Z1-Z2; Z2-Z2; Zproject	Short term		Yes
		Medium term		
		Long term		
Average trip travel time on road network by car	Z1-Z1; Z1-Z2; Z2-Z2	Short term		Yes
		Medium term		
		Long term		
Average trip travel time on the new project	Zproject	Short term		Yes
		Medium term		
		Long term		

3.2.2.4 Transport environment

The assessment of the environmental impacts of the infrastructure include air pollution and safety data.

	Indicators	Zone	Time horizon	Hypotheses with respect to Reference Scenario	Needed for WP10
Air pollution on main chemical effluents emissions	**CO**	Whole conur-bation	Short term	The new project implementation may have an impact on emissions. The change should be assessed.	Yes
			Medium term		
			Long term		
	CO_2		Short term		Yes
			Medium term		
			Long term		
	SOx		Short term		Yes
			Medium term		
			Long term		
	NOx		Short term		Yes
			Medium term		
			Long term		
	Lead		Short term		Yes
			Medium term		
			Long term		
	VOC		Short term		Yes
			Medium term		
			Long term		
	PM10		Short term		Yes
			Medium term		
			Long term		
Safety	**Number of fatalities**	Whole conur-bation	Short term	The new project may have an impact on the level of safety. It should be assessed.	Yes
			Medium term		
			Long term		
	Number of injured people	Whole conur-bation	Short term		Yes
			Medium term		
			Long term		
	Total casualties	Whole conur-bation	Short term		Yes
			Medium term		
			Long term		

3.3 Description of the data collection methodology

Data collection has been the responsibility of each case study partner using the methodology defined in work package 4. Each case study partner has used the previous tables which have been sent in an Excel sheet with information about unit for each indicator and a commentary when necessary.

Each partner was asked to send the corresponding sheet with comments on the method of collection and additional comments when necessary. This has been synthesised for each case study in sections 11.1.6 to 11.13.6.

In general data for the before scenario and the scenario with have mainly been collected from existing mobility surveys, census, report from transport operators or transport authorities. Some data was not available and as time dedicated to ***TranSEcon*** was not sufficient to organise specific survey production. Therefore in these cases, the corresponding data have not been produced by the case study partner.

For reference scenario the situation is most variable. Where model was available data have been computed (in this case for some case studies, some data have been computed for both reference scenario and scenario with in order to ensure the coherence of data). In other cases data have calculated from analysis of existing data.

3.4 General comments on data quality

Data collection has been much more time consuming than expected for all case study partners because some data was not easily available in existing surveys or reports. In this case some additional works has been necessary to calculate the data or to collect data from different actors of urban transport system.

In some other cases, data are still not produced by case study partners because the information is not accessible. For example in Great Britain, the deregulation of the bus sector has meant that data has become too strategic to divulge.

Another difficulty was the absence of a definition of a common reference scenario in work package 2. The same definition in all case studies has not been possible even if all partners have chosen a “do-minimum scenario”. Furthermore, the construction of the reference scenario is also quite complex because it does not correspond to an existing situation. For some partners, the availability of a model has overcome this difficulty. But for other partners data have been estimated from complex analysis of existing data.

The combination of multiple sources or methods to produce the data has resulted some-times in a lack of coherence. For example it could the case between the evolution of the number of trips and the evolution of the number of passenger*kilometres which can be produced from different sources. Where possible all coherence checks have been made, but some problems still remain.

Therefore some caution is still necessary when analysing the data and the trends are perhaps more relevant than the exact figures given in the different tables.

In the appendix figures are given with a certain precision. But the limits encountered in data collection, especially for reference scenario, should be remembered in its interpretation as the precision may be illusory. In most cases observed variation are too small to be really significant but indicate the direction of the change of the effect on transport.

3.5 Impact calculation method

The calculation of the impact of the public transport investment involved in the case study is defined by the methodology adopted in deliverable 2. For one indicator, the impact of the project corresponds to the difference between the value of this indicator for scenario with project and the value of the same indicator for reference scenario. With this calculation we define the absolute variation:

Absolute variation = $(Data"with" - Data"RS")$,

With:

$Data"with"$: data for the scenario with project;

$Data"RS"$: data for the reference scenario.

From this absolute variation, it is possible to calculate the relative variation of the indicator with the following formula:

Relative variation = $((Data"with" - Data"RS")/Data"RS")$.

For eleven project the definition of the reference scenario corresponds to the definition of a do minimum scenario with the production of the data for this scenario (see Table 4-4). In this case, it is possible to apply this method directly. But for two case studies (Bratislava and Zurich) the reference scenario correspond to a reference area where it is supposed that the project have no or minimum impact. In this case, it is not possible to apply directly the above formula. To keep the same principle of calculation we propose to define the impact as the difference between the growth of one indicator in the impacted area with the growth of the same indicator in the reference area. Therefore it is no more possible to calculate the absolute variation, but only the relative variation with the following formula (for example for one indicator in zone Z1 and for short term):

Relative variation =

$(Data"with"(ST,Z1) - Data"with"(Before,Z1))/Data"with"(Before,Z1) -$

$(Data(ST,ref\_area) - Data(Before,ref\_area))/Data(Before,ref\_area)$ With:

$Data"with"(ST,Z1)$: data for the scenario with project for zone Z1 for short term horizon;

$Data"with"(Before,Z1)$: data for the scenario with project for zone Z1 in the before situation;

$Data(ST,ref\_area)$: data for the reference scenario for the reference area for short term horizon;

$Data(Before,ref\_area)$: data for the reference scenario for the reference area in the before situation.

This impact is calculated for each indicator, each zone and each time horizon.

3.6 How to perform the comparative analysis

For the comparative analysis, it is necessary to deal with the fact that time horizons are not always the same between case studies. This problem can be illustrated with the figure below (Figure 3-3) (assuming for simplicity of representation a linear development in effects).

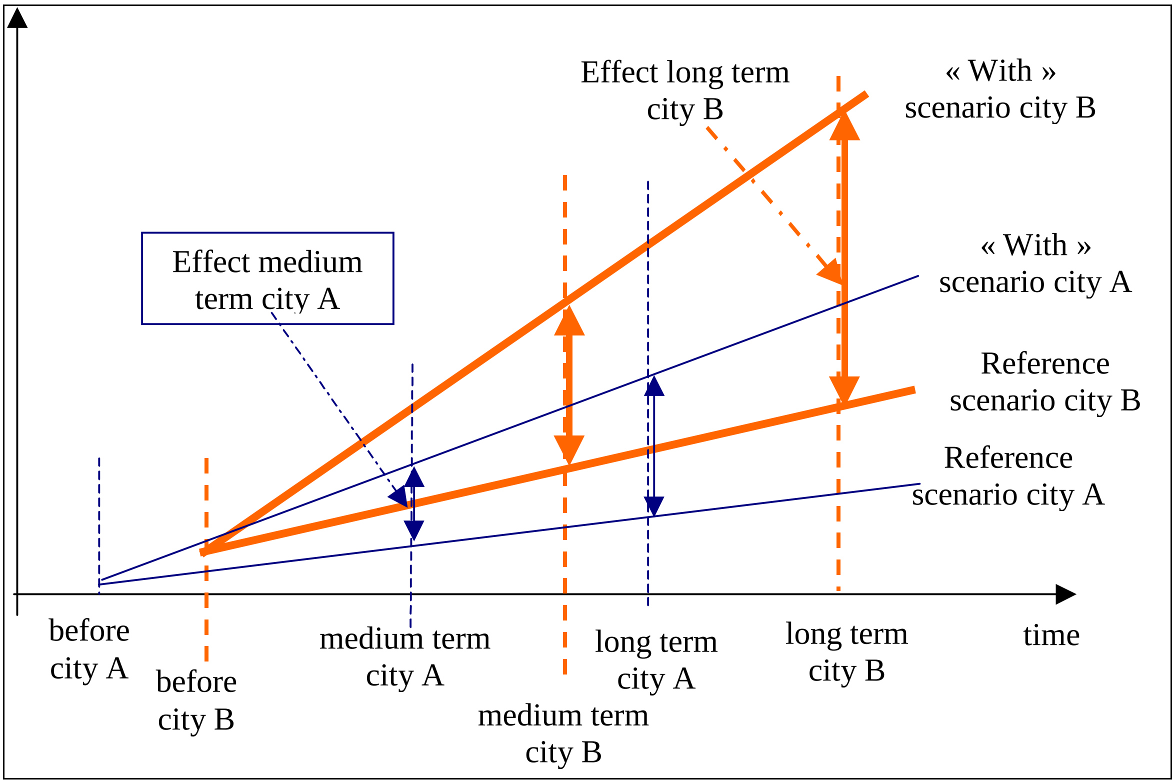

Figure 3-3: Illustration of the comparison problem with different time horizon

The direct comparison of absolute effect for short term and medium or long term could therefore conduct to misinterpretation. In order to face this problem, for the comparative analysis, results should be presented in terms of annualised variation.

Furthermore the indicators increase generally at a faster pace in short term than in medium and long term as shown in Figure 3-4. The development curve is non linear and may obviously differ between case studies for the same indicator.

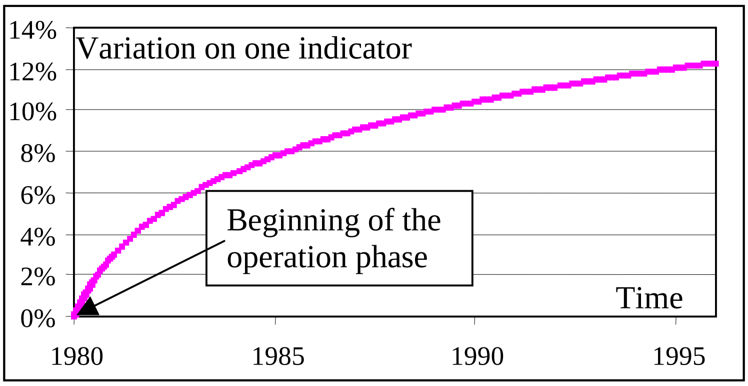

Figure 3-4: General evolution of variation of most indicators over time

Since it is impossible to calibrate different development curves for each case study, the best compromise found is to assume a *constant* annual growth ratio for each time horizon. Then annual growth ratio can be compared across case studies for the same time horizon, since time intervals (time horizon - time before) are broadly the same across case studies[6].

The "annualised effects" are calculated from the relative variation of the indicator (i.e. $(Data\text{"}with\text{"} - Data\text{"}RS\text{"})/Data\text{"}RS\text{"}$), then as a constant growth ratio per year on the time interval $Year\ Horizon - YearBefore$, the year horizon being for short, medium and long term. For all calculation the number of years between the time horizon and the year chosen for "before data" is considered. This year is preferred in lieu of the operation date because it allows to smooth the effects of the construction years which often introduce perturbation in transport system especially for public transport system. The formula is:

$$\left((1 + ((Data\text{"}with\text{"} - Data\text{"}RS\text{"})/Data\text{"}RS\text{"}))^{\frac{1}{Year\ Horizon - YearBefore}} \right) - 1$$

For the two case studies for which the reference scenario is defined by the reference area, we apply the same calculation but with the relative variation defined in the previous section (section 3.5).

This indicator allows to illustrate the decreasing effect which can be observed on most of the indicators for which both short, medium and long term data are available for one case study. But it should be noticed that it is not possible with this indicator to compare short term data of one case study with long term data of another case study. This calculation is represented inFigure 3-5. In this Figure 3-5 we have the following results:

[6] i.e. short term 2-4 years after the investment, medium term 4-6 years after the investment, long term about 10 years after the investment.

- short term effect (1985), relative variation = 7.78%; annualised effects = 1.51%;
- long term effect (1995), relative variation = 12.04%; annualised effects = 0.76%.

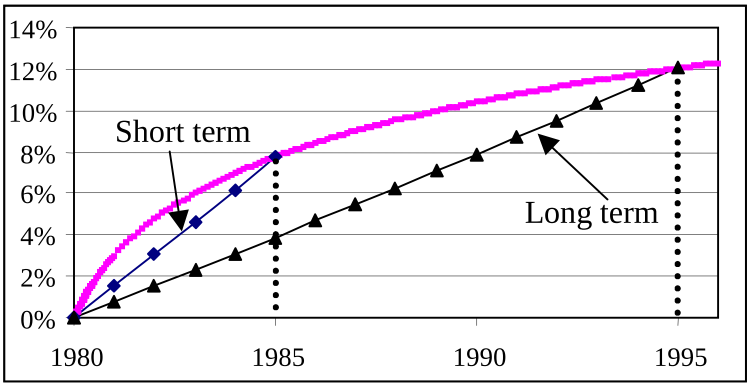

Figure 3-5: Illustration of the calculation of the “annualised effects” for short term (1985 in the figure) and long term (1995 in the figure)

4 CASE STUDY DESCRIPTION

This chapter gives an overview of the case-studies to facilitate the comparative analysis of transport related impact. The overview takes the same form as the case study descriptions which are presented for each case study in appendix 1.

4.1 Case study

Apart from Delft, all investment are public transport projects. All are heavy investments and are accompanied by reorganisation of the network. Nearly half concern light rail and the rest relate to metro system and S-Bahns (Stuttgart and Zurich). More than half are concerned with the centre of the conurbation whilst the rest deal with connections between suburbs and between the suburbs and centre of the conurbation. For half of the projects accompanying measures have been taken to restrict the use of car and increase the benefit of the project.

Case studies	Nature of the investment	Location of the investment	Length of the new infrastructure (km)	Accompanying measures
Athens	Metro line	Centre	18	Reorganisation of the network
Bratislava	Light rail + trolleybus lines	Centre	Light rail: 2.0 Trolleybus: 6.0	Transition economy period
Brussels	Inner ring metro line	Centre	8.2	No
Delft	Extensive bicycle network	Whole town	-	No
Helsinki	Metro line	Suburbs to centre	11.0	Reorganisation of the bus-service network
Lyon	Metro driverless line	Centre	15.0	Reorganisation of the network
Madrid	Inner ring metro line	Centre	7	Reorganisation of the network
Manchester	Metrolink light rail	Suburbs to centre	31	No
Stuttgart	S-Bahn	Suburbs	16	Parking restriction + park and ride + interoperability
Tyne and Wear	Metro light rail	Suburbs to centre	55.5	Park and ride
Valencia	Light rail	Suburbs to centre	9.7	Urban regeneration + integrated ticketing
Vienna	Metro line	Centre	8.2	Parking restriction + park and ride + urban regeneration
Zurich	S-Bahn	Central City and Suburbs	12	Strong restriction on public parking + public transport priority

Table 4-1: Case study description synthesis

4.2 Time scale project

Data are not always available for the required three time horizons. Furthermore the definition of the time horizon is not always identical between case studies. Impact analysis should take into account these elements.

Case studies	Operation since	Before	Short term	Medium term	Long term
Athens	2000	1996	2002	2006	n.a.
Bratislava	1988/89	1985	1990	1995	2000
Brussels	1988	1987/88	1989/90	1991/94	1998/2000
Delft	1985/86	1979/82	1987/90	1991/94	1995/96
Helsinki	1982	1981	1983/1985	1986/1988	1992/1995
Lyon	1992	1985/86	n.a.	1995	1999
Madrid	1995	1987/88	1996	2000	n.a.
Manchester	1992	1991	1996	2001	2011
Stuttgart	1992	1990	1994	1995 or 1997	2000
Tyne and Wear	1984	1980	1983/84	1986/88	1992/2002
Valencia	1994	1991	1996	2001	n.a.
Vienna	1991	n.a.	n.a.	n.a.	2002
Zurich	1990	1980/90	1990/93	1995/98	1999/2001

Table 4-2: Time scale synthesis

4.3 Zoning

For the ***TranSEcon*** project, the size of the conurbation varies from a small city like Delft to big conurbation like Madrid. Three groups can be identified:

- small city: Delft;
- medium conurbation: Bratislava, Helsinki, Lyon, Stuttgart, Tyne and Wear, Valencia, Vienna, Zurich;
- large conurbation: Athens, Brussels, Madrid and Manchester.

Several conurbations are the capital of their country and this explains some differences especially in term of financing the public transport network.

The sizes of the area included in (Z1 + Z2) are also very different. The area of Madrid and Brussels case studies are very large and are the biggest in terms of population. Stuttgart and Valencia are next with large Z1 + Z2 area (if smaller than Madrid and Brussels). For the other conurbations where the information is available, the surface of the study area is relatively comparable.

Big differences in terms of density are also observable. But the comparison is not, always easy because the surfaces of the study areas are different. Athens, Madrid and Valencia have the highest density in their conurbation centre. On the opposite

Zurich and Stuttgart for the centre of the conurbation have the lowest density. The situation is more comparable for the other conurbation.

Case studies	Indicator	Whole conurbation	Zproject	Z1 zone	Z2 zone
Athens	Population in 2002 (thousand)	4 000	997	1 519	1 278
	Surface in km^2	636	32.5	129.8	473.9
	Density in 2002 ($inhab/km^2$)	6 289	30 674	11 698	2 596
	Employment in 1996 (thousand)	n.a.	384	565	447
Bratislava	Population (thousand, in 1998)	450	Zp1: 0.4 Zp2: 30	422	27
	Surface in km^2	369	Zp1: 2.0 Zp2: 4.5	218	149
	Density ($inhab/km^2$, in 1998)	1 218	Zp1: 210 Zp2: 6556	1 932	179
	Employment (thousand)		Zp1: 4.5 Zp2: 22	212	23
Brussels (2001)	Population (thousand)	2 945	n.a.	954	1 980
	Surface in km^2	4 332	n.a.	161	4 170
	Density ($inhab/km^2$)	680	n.a.	5 980	475
	Employment (thousand)	1 353	n.a.	657	696
Delft (2002)	Population (thousand)	n.a.	n.a.	96.9	n.a.
	Surface in km^2	n.a.	n.a.	26.3	n.a.
	Density ($inhab/km^2$)	n.a.	n.a.	3 684	n.a.
	Employment (thousand)	n.a.	n.a.	50.8	n.a.
Helsinki (2000)	Population (thousand)	967	183	167	363
	Surface in km^2	764	43	39	117
	Density ($inhab/km^2$)	1 266	4 261	4 301	3 107
	Employment (thousand)	500	n.a.	n.a.	n.a.
Lyon (1999)	Population (thousand)	1 167	96	430	737
	Surface in km^2	487.2	8.6	65.3	421.9
	Density ($inhab/km^2$)	1 513	11 130	6 579	2 766
Madrid (2000)	Population (thousand)	5 205	190	2 882	2 322
	Surface in km^2	8 029	8.9	607.1	7 422
	Density ($inhab/km^2$)	648	21 356	4 748	312
	Employment (thousand)	2 036	102	1 402	633
Manchester (1991)	Population (thousand)	2 440	53	1 071	1 369
Stuttgart (2000)	Population (thousand)	1 376	n.a.	584	792
	Surface in km^2	2 066	16	207	1 859
	Density ($inhab/km^2$)	666	n.a.	2 816	426

Tyne and Wear (1996)	Population (thousand)	1 100	n.a.	n.a.	n.a.
Valencia (2001)	Population (thousand)	1 503	144	747	756
	Surface in km^2	1 231	20.2	99.7	1 131
	Density (inhab/km^2)	1 221	14 088	7 489	668
Vienna (2001)	Population (thousand)	1 562	n.a.	18	1 545
	Surface in km^2	418	n.a.	3	415
	Density (inhab/km^2)	3 765	n.a.	5 878	3 750
Zurich (population 2000, employment 1998)	Population (whole conurbation = Canton of Zurich, thousand)	1 207	34	334	133
	Surface in km^2	1 729	10.6	92	173
	Density (inhab/km^2)	698	3 285	3 634	766
	Employment (thousand)	693	21	315	58

Table 4-3: Zoning synthesis

Employment level are available for seven conurbation only. Except Athens, these conurbation show a strong concentration of the employment in the central area of the conurbation.

Of course these differences have strong consequences in terms of modal share. From the literature it is known that, anything else being equal, bigger conurbations have higher usage of public transport; higher density corresponds to higher use of public transport and higher concentration of employment in central area is synonymous of higher use of public transport.

4.4 Reference scenario

For analysis all projects, except Bratislava and Zurich, have adopted a do-minimum scenario i.e. a scenario where the investment would not have been built, but where all other elements of the transport policy (both for public and private transport and parking) would have to remain identical. Where a model was available, data have been estimated from modelling exercises. In other case studies this do-minimum scenario resulted from analysis of the evolution of some indicators of the conurbation combined with the comparison of the evolution of the same indicators in other area.

In many cases, multiple sources of data have been necessary which explain, in same cases, some apparent inconsistencies in data. Thus caution is always necessary in analysing the data.

Of course these differences in the definition of the reference scenario imply a reduction of the comparability of the data. Caution if therefore necessary in analysing the data. We often recommend to take more attention of the tendencies rather than the exact figures.

Case studies	Reference scenario	Method of data production

	definition	for reference scenario
Athens	Do minimum	Data analysis
Bratislava	Reference zone	Data analysis
Brussels	Do minimum	Modelling
Delft	Do minimum	Data analysis + evaluation studies
Helsinki	Do minimum	Data analysis
Lyon	Do minimum	Data analysis
Madrid	Do minimum	Modelling
Manchester	Do minimum	Modelling
Stuttgart	Do minimum	Modelling
Tyne and Wear	Do minimum	Data analysis
Valencia	Do minimum	Data analysis
Vienna	Do minimum	Modelling
Zurich	Reference zone	Data analysis

Table 4-4: Reference scenario synthesis

5 COMPARATIVE ANALYSIS: URBAN TRANSPORT SYSTEM AND SUPPLY

Because of uncertainty and errors attached to measures and estimations of the effects the computation of “annualised effects” must not use too much precision thus “annualised effects” are calculated as the relative variation of the indicator, i.e. $(Data\ "with" - Data\ "RS")/Data\ "RS"$, then as a growth ratio per year on the time interval $Year\ Horizon - YearBefore$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

5.1 Public transport system

Case studies	**Total amount of the investment (2002 cost base year)**	**Investment per kilometre (see** Table 4-1)
Athens	1 916 million Euro	106 million Euro
Bratislava	17 million Euro	2 million Euro
Brussels	357 million Euro	44 million Euro
Delft	13 million Euro (bicycle project)	
Helsinki	425 million Euro	39 million Euro
Lyon	524 million Euro	35 million Euro
Madrid	258 million Euro	37 million Euro
Manchester	181 million Euro	6 million Euro
Stuttgart	30 million Euro	2 million Euro
Tyne and Wear	1 655 million Euro	30 million Euro
Valencia	93 million Euro	10 million Euro
Vienna	1 936 million Euro	236 million Euro
Zurich	421 million Euro	35 million Euro

Table 5-1: Amount of investment of the public transport projects (except Delft bicycle project)

Even if the investment is quite important for some conurbation, the increase in public transport supply expressed in number of seat*kilometre is quite limited when compared to the supply at the level of the whole conurbation except in the case of Tyne and Wear (Table 5-2). Project can be classified in relation with the progression of supply:

- low progression: Bratislava, Brussels, Madrid, Valencia and Vienna;
- medium progression: Helsinki, Lyon and Manchester;
- High progression: Tyne and Wear.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens						**No data**
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
	Z1+Z2	+	+0.5%	+0.3%	+0.1%	Light rail + trolleybus lines
	Zproject	+	+0.5%	+0.2%	+0.1%	
Brussels				**1994**	**2000**	**Before: 1987**
	Z1	+	n.a.	+1 %	+0.5%	Inner ring metro line
	Z2	=	n.a.	0	0	
Delft			**1987**	**1990**	**1995**	**Before: 1979**
	Z1+Z2	=	0	0	0	Extensive bicycle network
Helsinki			**1984**	**1986**	**1992**	**Before: 1981**
	Z1+Z2	+	+5%	+4%	+2%	Metro line
	Zproject	+	+35%	+18%	+8%	
Lyon				**1995**	**1999**	**Before: 1986**
	Z1+Z2	+	n.a.	+2%	+2%	Metro line
Madrid			**1996**	**2000**		**Before: 1987**
	Z1+Z2	+	+1%	+0.6%	n.a.	Inner ring metro line
	Zproject	+	+11%	+7%	n.a.	
Manchester			**1993**	**1996**	**2001**	**Before: 1991**
	Zproject	+	+12%	+7%	+3%	Light rail
Stuttgart						**No data**
Tyne and Wear			**1983**	**1986**	**1992**	**Before 1980**
	Z1+Z2	+	+22%	+9%	+9%	Light rail
Valencia			**1996**	**2001**		**Before 1991**
	Z1+Z2	+	+1%	+0.6%	n.a.	Light rail
Vienna					**2002**	**Before: 1991**
	Z1+Z2	+	n.a.	n.a.	+0.5%	Metro line
	Z1+Z2a	+	n.a.	n.a.	+2%	
	Z1+Z2b	+	n.a.	n.a.	+0.2%	
	Zproject	+	n.a.	n.a.	+3%	
Zurich						**No data**

Table 5-2: Synthesis table of public transport capacity in number of seat kilometre (annualised variations)

The supply has not change in Delft which is a bicycle case study. The information is not available for the other case studies.

The impacts of the public transport investments on financial public transport indicators are always very limited (Table 5-3). At the level of the conurbation, the evolution is always smaller than the evolution of supply. For most case studies the evolution are so limited that they are probably inside the interval of confidence of the results.

It can only be observed greater evolution at the level of shorter zone directly concerned by the investment. But the information is available only for Bratislava, Helsinki, Madrid and Vienna. In all conurbations (except Bratislava) there is an increase of revenue for Zproject zone and also for trips inside Z1+Z2a zones which are the zones directly affected by the investment in case of Vienna. In the same time the increase of cost is more limited or even there is a decrease like in Helsinki which conduct to a reduction of public transport deficit and even an increase of benefice in case of Madrid.

In any case, the projects have very marginal consequences on contribution of the public authority to public transport finance.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens						**No data**
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
Annual fare revenues	Z1+Z2	**-**	-0.2%	-0.1%	-0.1%	Light rail + trolleybus lines
	Zproject	**+/-**	+2%	+0.2%	-0.5%	
Annual operation costs	Z1+Z2	**+**	+0.3%	+0.7%	+2%	
	Zproject	**-/+**	-2%	-0.8%	+0.1%	
Annual operation result	Z1+Z2	**+**	+0.6%	+1%	+2%	
	Zproject	**-**	-5%	-2%	-0.1%	
Brussels				**1994**	**2000**	**Before: 1987**
Annual fare revenues	Z1	**+**	n.a.	+0.1%	+0.1%	Inner ring metro line
	Z2	**=**	n.a.	0	0	
Annual operation costs	Z1	**-**	n.a.	-0.0%	-0.0%	
Annual operation result	Z1	**-**	n.a.	-0.1%	-0.4%	
Delft						**No data**
Bicycle project						
Helsinki			**1984**	**1986**	**1992**	**Before: 1981**
Annual fare revenues	Z1+Z2	**=**	0	0	0	Metro line
	Zproject	**+**	+0.6%	+0.3%	+0.2%	
Annual operation costs	Z1+Z2	**-**	-0.8%	-0.5%	-0.2%	
	Zproject	**-**	-4%	-2%	-1%	
Annual operation result	Z1+Z2	**-**	-2%	-1%	-0.4%	
	Zproject	**-**	-11%	-8%	-3%	

Annual contribution of transport authority to public transport	Z1+Z2	**-**	-4%	-1%	-0.4%	
Lyon				**1995**	**1999**	**Before: 1986**
Annual fare revenues	Z1+Z2	**+**	n.a.	+2%	+1%	Metro line
Annual operation costs	Z1+Z2	**+**	n.a.	+0.7%	+0.9%	
Annual operation result	Z1+Z2	**+/-**	n.a.	-0.5%	+0.8%	
Annual investment	Z1+Z2	**=**	n.a.	0	0	
Annual contribution of transport authority to public transport	Z1+Z2	**=**	n.a.	0	0	
Madrid			**1996**	**1995**		**Before: 1987**
Annual fare revenues	Z1+Z2	**+**	+0.7%	+1%	n.a.	Inner ring metro line
	Zproject	**+**	+10%	+4%	n.a.	
Annual operation costs	Z1+Z2	**+**	+0.4%	+0.2%	n.a.	
	Zproject	**+**	+6%	+4%	n.a.	
Annual operation result	Z1+Z2	**+/-**	+0.1%	-1%	n.a.	
	Zproject	**+/-**	-7%	+8%	n.a.	
Annual investment	Z1+Z2	**+**	+0.6%	+0.4%	n.a.	
Annual contribution of transport authority to public transport	Z1+Z2	**+**	+0.1%	+0.1%	n.a.	
Manchester						**No data**
Data not available in a context of public transport deregulation						
Stuttgart						**No data**
Tyne and Wear						**No data**
Data not available in a context of public transport deregulation						
Valencia			**1996**	**2001**		**Before: 1991**
Annual fare revenues	Z1+Z2	**+**	+0.5%	+0.5%		Light rail

Vienna					**2002**	**Before: 1991**
Annual fare revenues	Z1+Z2	**+**	n.a.	n.a.	+0.2%	Metro line
	Z1+Z2a	**+**	n.a.	n.a.	+1.9%	
	Z1+Z2b	**-**	n.a.	n.a.	-0.9%	
	Zproject	**+**	n.a.	n.a.	+4.2%	
Annual operation costs	Z1+Z2	**+**	n.a.	n.a.	+0.2%	
	Z1+Z2a	**+**	n.a.	n.a.	+0.5%	
	Z1+Z2b	**+**	n.a.	n.a.	+0.3%	
	Zproject	**+**	n.a.	n.a.	+2%	
Annual operation result	Z1+Z2	**+**	n.a.	n.a.	0.2%	
	Z1+Z2a	**-**	n.a.	n.a.	-2.3%	
	Z1+Z2b	**+**	n.a.	n.a.	1.4%	
	Zproject	**-**	n.a.	n.a.	-2.5%	
Annual investment	Z1+Z2	**+**	n.a.	n.a.	+0.6%	
Annual contribution of transport authority to public transport	Z1+Z2	**+**	n.a.	n.a.	+0.1%	
Zurich						**No data**

Table 5-3: Synthesis table of financial indicators of public transport (annualised variations)

5.2 Private transport system

Logically the public transport investments have no or very small effect on car ownership (Table 5-4). The effect of public transport policy on car ownership can be observed only on long term when a global and coherent transport policy at the level of the whole conurbation with important car use restriction is introduced. Furthermore the determinants of car ownership are not only related to urban car policy but also to the transport policy conducted at the national level and also of course to household revenues.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens			**2002**			**Before: 1996**
	Z2	**-**	-0.5%	n.a.	n.a.	Metro line
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
	Z1	**+/-**	-1%	+1%	+2%	Light rail + trolleybus lines
	Z2	**+/-**	-1%	+1%	+2%	
Brussels				**1994**	**1998**	**Before: 1987**
	Z1	**=**	n.a.	0	0	Inner ring metro line
	Z2	**=**	n.a.	0	n.a.	

Delft			**1987**	**1990**	**1995**	**Before: 1985**
	Z1	**+/-**	+1%	-0.3%	-1%	Extensive bicycle network
Helsinki			**1985**	**1988**	**1995**	**Before: 1981**
	Z1	**=**	0	0	0	Metro line
	Z2	**=**	0	0	0	
Lyon				**1995**	**2000**	**Before: 1985**
	Z1	**-/=**	n.a.	0	-0.3%	Metro line
	Z2	**=**	n.a.	0	0	
Madrid			**1996**	**2000**		**Before: 1987**
	Z1	**=**	0	0	n.a.	Inner ring metro line
	Z2	**=**	0	0	n.a.	
Manchester						**No data**
Stuttgart			**1994**	**1997**	**2000**	**Before: 1990**
	Z1	**=**	0	0	0	S-Bahn
	Z2	**-**	-0.1%	-0.1%	-0.1%	
	Z2a	**-**	-0.2%	-0.2%	-0.2%	
	Z2b	**-**	-0.1%	-0.1%	-0.1%	
Tyne and Wear						**No data**
Valencia			**1996**	**2001**		**Before: 1991**
	Z1	**=**	0	0	n.a.	Light rail
Vienna					**2002**	**Before: 1991**
	Z1	**=**	n.a.	n.a.	0	Metro line
	Z2	**=**	n.a.	n.a.	0	
	Z2a	**=**	n.a.	n.a.	0	
	Z2b	**=**	n.a.	n.a.	0	
	Z1+Z2	**=**	n.a.	n.a.	0	
Zurich			**1990**	**1995**	**2000**	**Before: 1985**
	Z1	**-**	-0.9%	-2%	-2%	S-Bahn
	Z2	**-**	-0.5%	-0.2%	-0.1%	
	Z1	**-**	-0.3%	-0.0%	-0.1%	
	Z2	**-**	-1%	-0.6%	-0.3%	

Table 5-4: Synthesis table of number of passenger cars per 1 000 inhabitants (annualised variations, see calculation section)

For all the conurbation, due to the definition of the reference scenario i.e. a do minimum scenario where the car policy remain unchanged, there is no change in the length of expressway, nor the construction of ring road, nor infrastructure investment nor traffic calming measure (Table 5-5).

But if the policy remain unchanged, it no more the case of car speed in four case studies (Athens, Bratislava, Lyon, Manchester, Stuttgart and Vienna). In Manchester the evolution are too small to be really significant. In case of Athens, Lyon and Vienna which are metro project an increase of car speed is observed. This would mean that metro project may have a more favourable impact on car speed (by an increase of car speed) than light rail project. In the case of underground, the road infrastructure remains very often quite stable or even increases with less bus (in the Lyon case) or light rail (in the case of Vienna) in the traffic. Furthermore modal shift reduce car traffic at least at short term (because at more longer term induced traffic can limit the reduction). On the contrary with light rail project a part of the road infrastructure is suppressed for car traffic. Modal shift seems to compensate this decrease with in general a stable car speed or even decrease of the speed of car like in Bratislava.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens			**2002**			**Before: 1996**
Average speed of trips by car (peak period)	Z1-Z1	+	+0.5%	n.a.	n.a.	Metro line
	Z2-Z2	+	+1%	n.a.	n.a.	
	Zproject	+	+2%	n.a.	n.a.	
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
Average speed of trips by car	Z1-Z1	-	-0.7%	-1%	-0.8%	Light rail + trolleybus lines
	Z1-Z2	-	-0.6%	-0.6%	-0.5%	
	Z2-Z2	-	-0.3%	-0.5%	-0.9%	
Length of the expressways	Z1+Z2	+	+7%	+9%	+8%	
Investment expenditures for increasing urban road network	Z1+Z2	-/+	-0.3%	+0.1%	+0.9%	
Brussels				**1994**	**1998**	**Before: 1987**
Average speed of trips by car	Z1-Z1	=	n.a.	0	0	Inner ring metro line
	Z1-Z2	=	n.a.	0	n.a.	
	Z2-Z2	=	n.a.	0	n.a.	
Length of the expressways	Z1+Z2	=	n.a.	0	0	
Complete circular road with express way	Z1+Z2	=	n.a.	0	0	

Delft			**1987**	**1990**	**1995**	**Before: 1980**
Average speed of trips by car	Z1-Z1	=	0	0	0	Extensive bicycle network
Length of the expressways	Z1+Z2	=	0	0	0	
Complete circular road with express way	Z1+Z2	=	0	0	0	
Helsinki			**1985**	**1988**	**1995**	**Before: 1981**
Average speed of trips by car	Z1-Z1	=	0	0	0	Metro line
	Z1-Z2	=	0	0	0	
	Z2-Z2	=	0	0	0	
Length of the expressways	Z1+Z2	=	0	0	0	
Complete circular road with express way	Z1+Z2	=	0	0	0	
Investment expenditures for increasing urban road network	Z1+Z2	-	-12%	-7%	-3%	
Lyon				**1995**	**2000**	**Before: 1985**
Average speed of trips by car	Z1-Z1	+	n.a.	+0.6%	+1%	Metro line
	Z1-Z2	+	n.a.	+1%	+0.8%	
	Z2-Z2	+	n.a.	+0.9%	+0.4%	
Length of the expressways	Z1+Z2	=	n.a.	0	0	
Complete circular road with express way	Z1+Z2	=	n.a.	0	0	
Madrid			**1996**	**2000**		**Before: 1987**
Average speed of trips by car	Z1-Z1	=	0	n.a.	n.a.	Inner ring metro line
Length of the expressways	Z1+Z2	=	0	0	n.a.	
Complete circular road with express way	Z1+Z2	=	0	0	n.a.	
Investment expenditures for increasing urban road network	Z1+Z2	=	0	0	n.a.	

Manchester			**1993**	**1996**	**2001**	**Before: 1991**
Average speed of trips by car	Z1-Z1	**=**	0	0	0	Light rail
	Z1-Z2	**+**	+0.2%	+0.1%	+0.0%	
	Z2-Z2	**=**	0	0	0	
Length of the expressways	Z1+Z2	**=**	0	0	0	
Complete circular road with express way	Z1+Z2	**=**	0	0	0	
Stuttgart			**1994**	**1995**	**2000**	**Before: 1990**
Average speed of trips by car	Z1-Z1	**=**	n.a.	0	n.a.	S-Bahn
	Z1-Z2a	**+**	n.a.	+0.2%	n.a.	
	Z2a-Z2a	**+**	n.a.	+0.1%	n.a.	
Length of the expressways	Z1-Z1	**=**	0	0	0	
	Z1-Z2a	**=**	0	0	0	
	Z1-Z2b	**=**	0	0	0	
Tyne and Wear						**No data**
Valencia			**1996**	**2001**		**Before: 1991**
Length of the expressways	Z1+Z2	**=**	0	0	n.a.	Light rail
Complete circular road with express way	Z1+Z2	**=**	0	0	n.a.	

Vienna					**2002**	**Before: 1991**
Average speed of trips by car	Z1	**+**	n.a.	n.a.	+0.9%	Metro line
	Z2a	**+**	n.a.	n.a.	+1.9%	
	Z2b	**+**	n.a.	n.a.	+1.4%	
	Z1 + Z2	**+**	n.a.	n.a.	+1.5%	
	Z1 + Z2a	**+**	n.a.	n.a.	+1.7%	
	Z1 + Z2b	**+**	n.a.	n.a.	+1.4%	
	Zproject	**+**	n.a.	n.a.	+1.6%	
Length of the expressways	Z1-Z1	**=**	n.a.	n.a.	0	
	Z1-Z2a	**=**	n.a.	n.a.	0	
	Z1-Z2b	**=**	n.a.	n.a.	0	
Complete circular road with express way	Z1-Z1	**=**	n.a.	n.a.	0	
	Z1-Z2a	**=**	n.a.	n.a.	0	
	Z1-Z2b	**=**	n.a.	n.a.	0	
Road with traffic calming measures [km²]	Z1	**=**	n.a.	n.a.	0	
	Z2a	**=**	n.a.	n.a.	0	
Investment expenditures for increasing urban road network	Z1+Z2	**=**	n.a.	n.a.	0	
Zurich			**1990**	**1993**	**1997**	**Before 1989**
Length of the expressways	Z1	**=**	0	0	0	S-Bahn
	Z2	**=**	0	0	0	
	Z2a	**=**	0	0	0	
	Z2b	**=**	0	0	0	

Table 5-5: Synthesis table of car infrastructure supply indicators (annualised variations)

Again there is no change (except Lyon case study) in parking supply. It's the result of the definition of the reference scenario which considers that the parking policy remains stable.

When the information is available, there is modification of parking use (except Lyon but the change is very small). It would be necessary to change radically parking policy at the same time than public transport investment to obtain significant change in parking behaviour. But this kind of policy was not decided in the definition of reference scenario of each case study (except Lyon, but again the policy was not really changed with an increase of parking capacity in reference scenario).

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens						**No data**
Bratislava						**No data**
Brussels				**1994**	**1998**	**Before: 1987**
Capacity of public (off street) car parks	Z1	**=**	n.a.	0	n.a.	Inner ring metro line
On-street parking slots	Z1	**=**	n.a.	0	n.a.	
Average on-street parking occupation rate	Z1	**=**	n.a.	0	n.a.	
Number of parking slots of park and ride facilities	Zproject	**=**	n.a.	0	0	
	Z1	**=**	n.a.	0	0	
Delft						**No data**
Bicycle project						
Helsinki			**1985**	**1988**	**1995**	**Before: 1981**
Capacity of public (off street) car parks	Z1	**=**	0	0	0	Metro line
On-street parking slots	Z1	**=**	0	0	0	
Private supply	Z1	**=**	0	0	0	
Average on-street parking occupation rate	Z1	**=**	0	0	0	(*) there is no parking slots of park and ride facilities in reference but 750 in scenario with
On-street parking turnover rate	Z1	**=**	0	0	0	
Number of parking slots of park and ride facilities	Zproject	**+**	*	*	*	

Lyon				**1995**	**2000**	**Before: 1985**
Capacity of public (off street) car parks	Z1	**-**	n.a.	-3%	-2%	Metro line (*) there is no parking slots of park and ride facilities in reference but 2 046 in scenario with
On-street parking slots	Z1	**=**	n.a.	0	0	
Average on-street parking occupation rate	Z1	**+**	n.a.	+0.1%	+0.2%	
On-street parking turnover rate	Z1	**+**	n.a.	+0.2%	+0.1%	
Number of parking slots of park and ride facilities	Zproject	**+**	n.a.	*	+13%	
	Z1+Z2	**+**	n.a.	+13%	+5%	
Madrid			**1996**	**2000**		**Before: 1987**
Capacity of public (off street) car parks	Z1	**=**	0	0	n.a.	Inner ring metro line
On-street parking slots	Z1	**=**	0	0	n.a.	
Private supply	Z1	**=**	0	0	n.a.	
On-street parking fee revenue	Z1	**=**	0	0	n.a.	
Number of parking slots of park and ride facilities	Zproject	**=**	0	n.a.	n.a.	
Manchester			**1993**	**1996**	**2001**	**Before: 1991**
Capacity of public (off street) car parks	Z1	**=**	n.a.	0	0	Light rail
On-street parking slots	Z1	**=**	n.a.	n.a.	0	
Average on-street parking occupation rate	Z1	**=**	0	0	0	
On-street parking turnover rate	Z1	**=**	0	0	0	
Stuttgart						**No data**
Tyne and Wear						**No data**

Valencia			**1996**	**2001**		**Before: 1991**
Capacity of public (off street) car parks	Z1	**=**	0	0	n.a.	Light rail
On-street parking slots	Z1	**=**	0	0	n.a.	
Number of parking slots of park and ride facilities	Zproject	**=**	0	0	n.a.	
	Z1	**=**	0	0	n.a.	
Vienna					**2002**	**Before: 1991**
Capacity of public (off street) car parks	Z1	**=**	n.a.	n.a.	0	Metro line
On-street parking slots	Z1	**=**	n.a.	n.a.	0	
Private supply	Z1	**=**	n.a.	n.a.	0	
Average on-street parking occupation rate	Z1	**=**	n.a.	n.a.	0	
On-street parking turnover rate	Zproject	**=**	n.a.	n.a.	0	
Number of parking slots of park and ride facilities	Zproject	**=**	n.a.	n.a.	0	
	Z1	**=**	n.a.	n.a.	0	
	Z2	**+**	n.a.	n.a.	+6%	
	Z2a	**=**	n.a.	n.a.	0	
	Z2b	**=**	n.a.	n.a.	0	
Zurich						**No data**

Table 5-6: Synthesis table of parking supply and demand indicators (annualised variations)

6 COMPARATIVE ANALYSIS: MOBILITY, TRIP BEHAVIOUR AND TIME SAVINGS

Because of uncertainty and errors attached to measures and estimations of the effects the computation of “annualised effects” must not use too much precision thus “annualised effects” are calculated as the relative variation of the indicator, i.e. $(Data\,"with" - Data\,"RS")/Data\,"RS"$, then as a growth ratio per year on the time interval $Year\ Horizon - YearBefore$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

6.1 Comparative analysis on trip behaviour

Table 6-1 shows the mobility indicators for each case study.

First of all it appears that the annual effects are for the most part very low. This has to do with the geographical scales at which these effects are measured. These geographical scales vary widely between case studies: in particular Z1 areas can be CBD or whole city within an urban area, while Z2 is mostly the whole urban area. On the same time the transport investments considered are less heterogeneous in scope.

However the directions of the variations are consistent with what can be reasonably expected:

- there is an increase effect on the number of public transport trips for all case studies (or on bicycle trips for Delft);
- at the level of the city (Z1) or urban area (Z2) effects are mostly low as already said, except for Tyne and Wear and Stuttgart: in both cases the project is an important investment at the urban area level;
- when data is available more specifically for the project (Zproject or Project only) the annualised effects are sometimes quite important: +6-7% for trips Lyon, -18% for pass-km in Madrid (reduction of trip lengths for public transport users), +11% for trips and pass-km in Manchester, +5-6% in Stuttgart, +4-5% in Valencia, +4% for pass-km in Vienna;
- the impact is always strongly decreasing over time horizon which indicates that the impact on public transport use is mainly a short term impact. After this short term impact, the impact of the project is no more identifiable and mixed with the general trend of public transport use.

- there is generally a decrease effect on car trips and car-km for all case studies or absence of effect: however when present this effect is systematically very low, i.e. less than 1% per year;
- modal share is available only in the case of Helsinki and Manchester. Manchester shows a significant increase of public transport share in Z1 area (core centre). However for other case studies it can be deduced from car and public transport trips indicators that the whole mobility is rather increased by the new public transport projects even if this in increase is very limited at the geographical scale of the conurbation: at the same time there is no or very low decrease of car mobility.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens						**No data**
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
Public transport trips per origin-destination	Z1-Z1	**+**	+0.7%	+0.2%	+0.1%	Light rail + trolleybus lines
	Z1-Z2	**+**	+0.7%	+0.2%	+0.1%	
	Z2-Z2	**+**	+0.7%	+0.2%	+0.1%	
	Zproject	**+**	+9%	+4%	+2%	
Public transport passenger-km per origin-destination	Z1-Z1	**+**	+1%	+0.5%	+0.2%	
	Z1-Z2	**+**	+1%	+0.5%	+0.2%	
	Z2-Z2	**+**	+1%	+0.5%	+0.2%	
	Z2-Z2	**+**	+1%	+0.5%	+0.2%	
Car trips per origin-destination	Z1-Z1	**–/+**	-3%	+1%	+1%	
	Z1-Z2	**–/+**	-3%	+1%	+1%	
	Z2-Z2	**–/+**	-3%	+1%	+1%	
Car km per origin-destination	Z1-Z1	**–/+**	-3%	+1%	+2%	
	Z1-Z2	**–/+**	-4%	+0.7%	-0.2%	
	Z2-Z2	**–/+**	-4%	+4%	+3%	
Walk trips per origin-destination	Z1-Z1	**+**	+0.5%	+0.1%	+0.6%	
Share of public transport per origin-destination	Z1-Z1	**+/-**	+3%	-2%	-0.5%	
	Z1-Z2	**+/-**	+2%	-2%	-0.9%	
Brussels				**1991**	**2000**	**Before: 1987**
Public transport trips per origin-destination	Z1-Z1	**+**	n.a.	+0.2%	+0.1%	Inner ring metro line
	Z1-Z2	**+**	n.a.	+0.2%	+0.1%	
	Z2-Z2	**=**	n.a.	0	0	
Car trips per origin-destination	Z1-Z1	**–**	n.a.	-0.2%	n.a.	
	Z1-Z2	**–**	n.a.	-0.2%	n.a.	
	Z2-Z2	**=**	n.a.	0	n.a.	
Car km per origin-destination	Z1-Z1	**–**	n.a.	-0.2%	n.a.	
	Z1-Z2	**–**	n.a.	-0.2%	n.a.	
	Z2-Z2	**=**	n.a.	0	n.a.	
Delft			**1990**	**1994**	**1996**	**Before: 1982**

Bicycle trips per origin-destination	Z1-Z1	+	+2%	+1%	+0.9%	Extensive bicycle network
	Z1-Z2	+	+2%	+1%	+0.8%	
Bicycle-km per origin-destination	Z1-Z1	+	+2%	+1%	+1%	
	Z1-Z2	+	+2%	+1%	+0.8%	
Car trips per origin-destination	Z1-Z1	–	-0.9%	-0.8%	-0.8%	
	Z1-Z2	–	-0.1%	-0.1%	-0.1%	
Car km per origin-destination	Z1-Z1	–	-0.7%	-0.7%	-0.7%	
	Z1-Z2	–	-0.1%	-0.0%	-0.0%	
Walk trips per origin-destination	Z1-Z1	–	-0.6%	-0.4%	-0.4%	
	Z1-Z2	–	-0.7%	-0.4%	-0.3%	
Helsinki			**1985**	**1988**	**1995**	**Before: 1981**
Public transport trips per origin-destination	Z1-Z1	=	0	0	0	Metro line
	Z1-Z2	+	+0.2%	+0.1%	+0.1%	
	Z2-Z2	-	-0.3%	-0.1%	-0.1%	
	Zproject	+	+0.4%	+0.2%	+0.2%	
Public transport passenger-km per origin-destination	Z1-Z1	=	0	0	0	
	Z1-Z2	+	+0.2%	+0.1%	+0.1%	
	Z2-Z2	-	-0.3%	-0.1%	-0.1%	
	Zproject	-	-0.6%	-0.4%	-0.1%	
Car trips per origin-destination	Z1-Z1	=	0	0	0	
	Z1-Z2	-	-0.2%	-0.1%	-0.0%	
	Z2-Z2	=/-	0	-0.1%	-0.1%	
Car km per origin-destination	Z1-Z1	=	0	0	0	
	Z1-Z2	-	-0.2%	-0.1%	-0.0%	
	Z2-Z2	=/-	0	-0.1%	-0.1%	
Share of public transport among motorised trips	Z1-Z1	=	0	0	0	
	Z1-Z2	+	+0.2%	+0.1%	+0.1%	
	Z2-Z2	-	-0.2%	-0.0%	-0.0%	
Lyon				**1995**	**1999**	**Before: 1984**
Public transport trips per origin-destination	Z1-Z1	+	n.a.	+0.5%	+0.3%	Metro line
	Z1-Z2	+	n.a.	+1%	+0.8%	
	Z2-Z2	+	n.a.	+0.1%	0	
	Project only	+	n.a.	+7%	+6%	
Public transport passenger-km per origin-destination	Z1-Z1	+	n.a.	+2%	+0.3%	
	Z1-Z2	+	n.a.	+2%	+1%	
	Z2-Z2	+	n.a.	+0.8%	+0.6%	
Car trips per origin-destination	Z1-Z1	–	n.a.	-0.5%	-0.3%	
	Z1-Z2	–	n.a.	-0.5%	-0.3%	
	Z2-Z2	–	n.a.	-0.2%	-0.1%	
Car km per origin-destination	Z1-Z1	–	n.a.	-0.5%	-0.3%	
	Z1-Z2	–	n.a.	-0.5%	-0.3%	
	Z2-Z2	–	n.a.	-0.2%	-0.1%	

Madrid			**1996**	**2000**		**Before: 1987**
Public transport trips per origin-destination	Z1-Z1	**=**	0	0	n.a.	Inner ring metro line
	Z1-Z2	**=**	0	0	n.a.	
	Z2-Z2	**=**	0	0	n.a.	
	Zproject	**+**	+0.1%	0	n.a.	
	Project only	**+**	+0.7%	+0.5%	n.a.	
Public transport passenger-km per origin-destination	Z1-Z1	**=**	0	0	n.a.	
	Z1-Z2	**=**	0	0	n.a.	
	Z2-Z2	**=**	0	0	n.a.	
	Zproject	**–**	-0.0%	-0.1%	n.a.	
	Project only	**+/-**	+0.2%	-0.3%	n.a.	
Manchester			**1993**	**1996**	**2001**	**Before: 1991**
Public transport trips per origin-destination	Z1-Z1	**+**	+26%	+10%	+5%	Light rail
	Z1-Z2	**+**	+3%	+1%	+0.8%	
	Z2-Z2	**+**	+0.2%	+0.1%	+0.1%	
	Project only	**+**	+29%	+12%	+6%	
Public transport passenger-km per origin-destination	Z1-Z1	**+**	+13%	+5%	+2%	
	Z1-Z2	**+**	+2%	+0.9%	+0.4%	
	Z2-Z2	**+**	+0.1%	+0.1%	+0.0%	
	Zproject	**+**	+29%	+11%	+5%	
Car trips per origin-destination	Z1-Z1	**=**	0	0	0	
	Z1-Z2	**–**	-0.4%	-0.2%	-0.1%	
	Z2-Z2	**=**	0	0	0	
Car km per origin-destination	Z1-Z1	**=**	0	0	0	
	Z1-Z2	**–**	-0.3%	-0.1%	-0.1%	
	Z2-Z2	**=**	0	0	0	
Walk trips per origin-destination	Z1-Z1	**–**	-6%	-3%	-2%	
	Z1-Z2	**=**	0	0	0	
Public transport modal share	Z1-Z1	**+**	+11%	+4%	+2%	
	Z1-Z2	**+**	+2%	+0.8%	+0.5%	
	Z2-Z2	**+**	+0.1%	+0.1%	+0.0%	

Stuttgart			**1994**	**1995**	**2000**	**Before: 1990**
Public transport trips per origin-destination	Z1-Z1	**+**	n.a.	+5%	n.a.	S-Bahn
	Z1-Z2a	**+**	n.a.	+5%	n.a.	
	Z2a-Z2a	**+**	n.a.	+5%	n.a.	
Public transport passenger-km per origin-destination	Z1-Z1	**+**	n.a.	+6%	n.a.	
	Z1-Z2a	**+**	n.a.	+6%	n.a.	
	Z2a-Z2a	**+**	n.a.	+6%	n.a.	
Car trips per origin-destination	Z1-Z1	**–**	n.a.	-2%	n.a.	
	Z1-Z2a	**–**	n.a.	-1%	n.a.	
	Z2a-Z2a	**–**	n.a.	-0.5%	n.a.	
Car km per origin-destination	Z1-Z1	**–**	n.a.	-0.2%	n.a.	
	Z1-Z2a	**–**	n.a.	-2%	n.a.	
	Z2a-Z2a	**–**	n.a.	-0.8%	n.a.	
Tyne and Wear			**1983**	**1986**	**1992**	**Before: 1980**
Public transport trips per origin-destination	Z1-Z1	**+**	+8%	+4%	+3%	Light rail
	Z1-Z2	**+**	+8%	+5%	+3%	
	Z2-Z2	**+**	+8%	+5%	+3%	
Public transport passenger-km per origin-destination	Z1-Z1	**+**	+4%	+4%	+3%	
	Z1-Z2	**+**	+9%	+5%	+2%	
	Z2-Z2	**+**	+9%	+5%	+2%	
Car trips per origin-destination	Z1-Z1	**=**	0	0	0	
	Z1-Z2	**–**	-0.9%	-0.5%	-0.4%	
	Z2-Z2	**=**	0	0	0	
Car km per origin-destination	Z1-Z1	**=**	0	0	0	
	Z1-Z2	**–**	-0.9%	-0.6%	-0.4%	
	Z2-Z2	**=**	0	0	0	
Valencia	**1991**		**1996**	**2001**		**Before: 1991**
Public transport trips per origin-destination	Z1-Z1	**=**	0	0	n.a.	Light rail
	Zproject	**+**	+2%	+2%	n.a.	
Public transport passenger-km per origin-destination	Z1-Z1	**=**	0	0	n.a.	
	Zproject	**+**	+5%	+4%	n.a.	

Vienna					**2002**	**Before: 1991**
Public transport trips per origin-destination	Z1-Z1	+	n.a.	n.a.	+0.3%	Metro line
	Z1+Z2	+	n.a.	n.a.	+0.2%	
	Z1-Z2a	+	n.a.	n.a.	+0.5%	
	Z1-Z2b	+	n.a.	n.a.	+0.1%	
	Z2a-Z2a	+	n.a.	n.a.	+0.4%	
	Z2a-Z2b	+	n.a.	n.a.	+0.2%	
	Z2b-Z2b	+	n.a.	n.a.	+0.1%	
	Zproject	+	n.a.	n.a.	+0.6%	
Public transport passenger-km per zone	Z1	+	n.a.	n.a.	+1.2%	
	Z2a	+	n.a.	n.a.	+1.8%	
	Z2b	–	n.a.	n.a.	-0.3%	
	Zproject	+	n.a.	n.a.	+3,6%	
Car trips per origin-destination	Z1-Z1	–	n.a.	n.a.	-0.2%	
	Z1-Z2a	–	n.a.	n.a.	-0.6%	
	Z1-Z2b	–	n.a.	n.a.	-0.2%	
	Z2a-Z2a	–	n.a.	n.a.	-0.4%	
	Z2a-Z2b	–	n.a.	n.a.	-0.2%	
	Z2b-Z2b	–	n.a.	n.a.	-0.1%	
	Zproject	–	n.a.	n.a.	-0.7%	
Car km per zone	Z1	–	n.a.	n.a.	-0.4%	
	Z2a	–	n.a.	n.a.	-0.7%	
	Z2b	–	n.a.	n.a.	-0.2%	
	Zproject	–	n.a.	n.a.	-0.7%	

Zurich			1992	1995	2000	Before 1989
Number of S-Bahn passengers entering and leaving the area of Zurich City (Z1 zone) on a working day		+	+8%	+4%	+1%	S-Bahn
Number of passengers of local and regional busses at a selection of cross-sections of the networks		+	+6%	+3%	n.a.	
Number of motor vehicles entering/leaving the area of Zurich city by highway from/to eastern part of the urban region (SN 1.4), in daily average (24h)		+	+1%	+0.9%	n.a.	

Table 6-1: Synthesis table of mobility indicators (annualised variations)

6.2 Comparative analysis on time savings

Table 6-2 shows the time savings indicators for each case study.

Here again most of the annualised effects are very low, for the same reasons quoted above for mobility indicators.

The directions of variations are also consistent with what is expected for public transport:

- there is a decrease annualised effect on travel time on the public transport network (or bicycle network for Delft) for all case studies;
- this decrease annualised effect is significant even important at the level of the project (Zproject or project only) for Athens (12-8%), Lyon (5-3%), Madrid (6-4%), Manchester (2%), Vienna (2%);
- this decrease annualised effect is significant at the level of the whole conurbation only for Stuttgart (6-8%) and Tyne and Wear (9-13% in short term, 5-7% in medium term).

However when it comes to road network, things are different. There is a stagnation and sometimes an annualised decrease effect on travel time by car on the road network. This effect when present is very low (less than 1%) except in Athens at short term (-2 –4%), Lyon (-2% in Z1 area, the city) and in Vienna (-2% in Zproject).

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens			**2002**	**2006**		**Before: 1996**
Average trip travel time on the public transport network	Z1-Z1	–	-4%	-3%	n.a.	Metro line
	Z1-Z2	–	-4%	-3%	n.a.	
	Z2-Z2	-	-2%	-1%	n.a.	
	Zproject	–	-12%	-8%	n.a.	
Average trip travel time on the road network	Z1-Z1	–/+	-4%	+0.3%	n.a.	
	Z1-Z2	–	-2%	-2%	n.a.	
	Z2-Z2	–/+	-4%	+0.7%	n.a.	
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
Average trip travel time on the public transport network	Z1-Z1	+	+1%	+1%	+1%	Light rail + trolleybus lines
	Z1-Z2	+	+0.9%	+0.4%	+0.7%	
	Z2-Z2	=/-/+	0	-1%	+0.3%	
	Zproject 1 (tram)	=/–	0	-1%	-1%	
	Zproject 2 (trolley-bus)	=/–/+	0	-0.6%	+0.1%	
Average trip travel time on the road network	Z1-Z1	=	0	0	0	
	Z1-Z2	–	-0.8%	-2%	-2%	
	Z2-Z2	–/+	-1%	+0.2%	+0.3%	
Brussels						**No data**
Delft			**1990**	**1994**	**1996**	**Before: 1982**
Average trip travel time on the bicycle network	Z1-Z1	+/–	-1%	+0.4%	-0.4%	Extensive bicycle network
	Z1-Z2	–	-0.4%	-0.4%	-0.2%	
Average trip travel time on the road network	Z1-Z1	=	0	0	0	
	Z1-Z2	=	0	0	0	
Helsinki			**1983**	**1988**	**1995**	**Before: 1981**
Average trip travel time on the public transport network	Z1-Z2	=/–	0	-0.0%	-0.0%	Metro line
	Zproject	+/-	+3%	-0.1%	-0.3%	
Average trip travel time on the road network	Z1-Z2	=	0	0	0	

Lyon				**1995**	**1999**	**Before: 1986**
Average trip travel time on the public transport network	Z1-Z1	–	n.a.	-1%	-0.3%	Metro line
	Z1-Z2	–	n.a.	-0.8%	-0.2%	
	Z2-Z2	=	n.a.	0	0	
	Zproject	–	n.a.	-5%	-3%	
Average trip travel time on the road network	Z1-Z1	–	n.a.	-2%	0	
	Z1-Z2	–	n.a.	-0.6%	0	
	Z2-Z2	–	n.a.	-0.6%	0	
Madrid			**1996**	**2000**		**Before: 1987**
Average trip travel time on the public transport network	Z1-Z1	=	0	0	n.a.	Inner ring metro line
	Z1-Z2	=	0	0	n.a.	
	Z2-Z2	=	0	0	n.a.	
	Zproject	–	-0.2%	-0.2%	n.a.	
	Project only	–	-6%	-4%	n.a.	
Manchester			**1993**	**1996**	**2001**	**Before: 1991**
Average trip travel time on the public transport network	Z1-Z1	=	0	0	0	Light rail
	Z1-Z2	–	-0.2%	-0.1%	-0.0%	
	Z2-Z2	=	0	0	0	
	Zproject	–	-4%	-0.8%	-0.6%	
Average trip travel time on the road network	Z1-Z1	=	0	0	0	
	Z1-Z2	–	-0.4%	-0.8%	-0.0%	
	Z2-Z2	=	0	0	0	
Stuttgart			**1994**	**1995**	**2000**	**Before: 1990**
Average trip travel time on the public transport network	Z1-Z1	–	n.a.	-0.3	n.a.	S-Bahn
	Z1-Z2a	–	n.a.	-6%	n.a.	
	Z2a-Z2a	–	n.a.	-8%	n.a.	
Average trip travel time on the road network	Z1-Z1	–	n.a.	-0.4%	n.a.	
	Z1-Z2a	–	n.a.	-0.4%	n.a.	
	Z2a-Z2a	–	n.a.	-0.6%	n.a.	
Tyne and Wear			**1983**	**1986**	**1992**	**Before: 1980**
Average trip travel time on the public transport network	Z1-Z1	–	-2%	-2%	n.a.	Light rail
	Z1-Z2	–	-13%	-7%	n.a.	
	Z2-Z2	–	-9%	-5%	n.a.	
Valencia			**1996**	**2001**		**Before: 1991**
Average trip travel time on the public transport network	Z1-Z1	=	0	0	n.a.	Light rail
	Zproject	=	0	0	n.a.	

Vienna					2002	Before: 1991
Average trip travel time on the public transport network	Z1-Z1	–	n.a.	n.a.	-0.8%	Metro line
	Z1+Z2	–	n.a.	n.a.	-0.5%	
	Z1-Z2a	–	n.a.	n.a.	-1.9%	
	Z1-Z2b	–	n.a.	n.a.	-0.6%	
	Z2a-Z2a	–	n.a.	n.a.	-1.3%	
	Z2a-Z2b	–	n.a.	n.a.	-0.6%	
	Z2b-Z2b	–	n.a.	n.a.	-0.2%	
	Zproject	–	n.a.	n.a.	-2.3%	
Average trip travel time on the road network	Z1-Z1	–	n.a.	n.a.	-0.3%	
	Z1+Z2	–	n.a.	n.a.	-0.2%	
	Z1-Z2a	–	n.a.	n.a.	-0.3%	
	Z1-Z2b	–	n.a.	n.a.	-0.2%	
	Z2a-Z2a	–	n.a.	n.a.	-0.5%	
	Z2a-Z2b	=	n.a.	n.a.	-0.3%	
	Z2b-Z2b	–	n.a.	n.a.	-0.2%	
	Zproject	–	n.a.	n.a.	-1.5%	
Zurich						**No data**

Table 6-2: Synthesis table of time savings indicators (annualised variations)

7 COMPARATIVE ANALYSIS: TRANSPORT ENVIRONMENT

Because of uncertainty and errors attached to measures and estimations of the effects the computation of "annualised effects" must not use too much precision thus "annualised effects" are calculated as the relative variation of the indicator, i.e. $(Data\ "with" - Data\ "RS")/Data\ "RS"$, then as a growth ratio per year on the time interval $Year\ Horizon - YearBefore$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

7.1 Environmental pollution

The volume of air pollutants cannot be considered because the spatial area of observation is very different between cities. Furthermore, the technical methods of measure vary between the countries.

The difference between transport projects as the implementation of a light rail line or an underground line should be taken into account to compare the environmental impacts.

The ***TranSEcon*** data are available only for nine case studies Bratislava, Delft, Helsinki, Lyon, Madrid, Stuttgart, Tyne and Wear, Valencia and Vienna) limiting the possibility of a comparative analysis. Furthermore, among these nine case studies, for three case studies partners estimate that change in emissions are null (or too small to be able to calculate them). However, data collected from the case studies are presented in the following table.

In all the case studies, the environmental impact of transport infrastructure was positive or null if we consider a negative variation of pollutants. In all case studies this reduction of effluent emissions is related to a decrease in car use. But except in the case of Bratislava, Helsinki and Vienna, it should be noted that the evolution are very small and probably not very significant. Therefore except for these conurbation, results should be taken with important caution. For these three conurbation there is an important decrease of emission for all effluents.

Case study	Zone	Direction	Short term	Medium term	Long term	Comments
Athens						**No data**
Bratislava			**1990**	**1995**	**2000**	**Before: 1985**
CO	(Z1 + Z2)	-	-2%	-2%	-2%	Light rail + trolleybus lines
NOx		-	-3%	-4%	-5%	
Brussels						
Delft			**1987**	**1990**	**1995**	
CO	Delft city	-	-0.2%	-0.5%	-0.3%	
CO2		-	-0.2%	-0.4%	-0.2%	
SOx		-	-0.1%	-0.4%	-0.2%	
NOx		-	-0.1%	-0.3%	-0.1%	
Lead		-	-0.2%	-0.5%	-0.2%	
VOC		-	-0.3%	-0.7%	-0.3%	
PM10		-	n.a.	n.a.	-0.2%	
Helsinki			**1985**	**1988**	**1995**	**Before: 1981**
CO	(Z1 + Z2)	-	-3%	-2%	-1%	Metro line
CO2		-	-0.9%	-0.6%	-0.2%	
SOx		+	+10%	+7%	+5%	
NOx		-	-3%	-2%	-1%	
Lead			n.a.	n.a.	n.a.	
VOC		-	-4%	-2%	-1%	
PM10		-	-3%	-2%	-1%	
Lyon				**1995**		
CO	(Z1 + Z2)	=	n.a.	0	n.a.	Metro line
CO2		=	n.a.	0	n.a.	
SOx		=	n.a.	0	n.a.	
NOx		=	n.a.	0	n.a.	
Lead		=	n.a.	0	n.a.	
VOC		=	n.a.	0	n.a.	
PM10		=	n.a.	0	n.a.	
Madrid			**1996**	**2000**		**Before: 1987**
CO	(Z1 + Z2)	=	0	0	n.a.	Inner ring metro line
CO2		=	0	0	n.a.	
SOx		=	0	0	n.a.	
NOx		=	0	0	n.a.	
Lead		=	0	0	n.a.	
VOC		=	0	0	n.a.	
PM10			n.a.	n.a.	n.a.	

Manchester						**No data**
Stuttgart				**1995**	**1999**	**Before: 1990**
CO	*SK Stuttgart, LK Boeblingen LK Calw, LK Tuebingen*	**-**	n.a.	-0.4%	-0.3%	S-Bahn
CO2		**-**	n.a.	-0.4%	-0.4%	
SOx		**+/-**	n.a.	+0.1%	-2%	
NOx		**-**	n.a.	-0.1%	-0.5%	
Lead			n.a.	n.a.	n.a.	
VOC			n.a.	n.a.	n.a.	
PM10			n.a.	n.a.	n.a.	
Tyne and Wear			**1983**	**1986**	**1992**	**Before: 1980**
CO	Z1 + Z2	**-**	-0.3%.	-0.1%	-0.1%	Light rail
CO2		**-**	-0.5%	-0.2%	-0.1%	
SOx		**-**	-0.6%	-0.3%	-0.1%	
NOx			n.a.	n.a.	n.a.	
hydrocarbon		**-**	-1%	-0.4%	-0.2%	
VOC			n.a.	n.a.	n.a.	
PM10		**-/=**	-2%	0	0	
Valencia			**1996**	**1999**		**Before: 1991**
CO	Z1 + Z2		n.a.	n.a.	n.a.	Light rail
CO2			n.a.	n.a.	n.a.	
SOx		**=**	0	0	n.a.	
NOx			n.a.	n.a.	n.a.	
Lead			n.a.	n.a.	n.a.	
VOC			n.a.	n.a.	n.a.	
PM10			n.a.	n.a.	n.a.	
Vienna					**2002**	**Before: 1991**
CO	Z1 + Z2	**-**	n.a.	n.a.	-0,5%	Metro line
CO2		**-**	n.a.	n.a.	-0,4%	
SOx		**-**	n.a.	n.a.	-0,4%	
NOx		**-**	n.a.	n.a.	-0,2%	
Lead			n.a.	n.a.	0,0%	
VOC		**-**	n.a.	n.a.	-0,4%	
PM10		**-**	n.a.	n.a.	-0,4%	
Zurich						**No data**

Table 7-1: Synthesis table of emission indicators (annualised variations)

7.2 Road safety

Again, data are available for 8 case studies only. Furthermore, there is no variation for four of them.

For this other five case studies, road safety has been improved thanks to car use reduction. These five case studies corresponds to different public transport investment. It should be noticed that except in the Bratislava case study, the variation are very small and probably not significant.

From these results, it is difficult to learn a lot about the safety benefits of transport infrastructure and to do definitive conclusions. The nature of the investment cannot explain a more positive impact than another investment. Accompanying measures can be as important as the infrastructure itself.

Case study	Direction	Short term	Medium term	Long term	Comments
Athens					**No data**
Bratislava					**No data**
Brussels			**1991**	**1998**	**Before: 1988**
Fatalities	=	n.a.	0	0	Inner ring metro line
Injured persons	=	n.a.	0	0	
Casualties	=	n.a.	0	0	
Delft		**1987**	**1990**	**1995**	**Before: 1980**
Fatalities	-	-1%	-0.2%	-0.1%	Data for Delft city
Injured persons	-	-1%	-0.2%	-0.1%	Extensive bicycle network
Casualties	-	-1%	-0.2%	-0.1%	
Helsinki		**1985**	**1988**	**1995**	**Before: 1981**
Casualties	-	-2%	-1%	-0.4%	Metro line
Lyon					**No data**
Madrid			**1996**	**2000**	**Before: 1987**
Fatalities	=	n.a.	0	0	Inner ring metro line
Injured persons	=	n.a.	0	0	
Casualties	=	n.a.	0	0	
Manchester					**No data**
Stuttgart		**1994**	**1995**	**1999**	**Before: 1990**
Fatalities	-	-1	-0.4%	-0.5%	S-Bahn
Injured persons	-	-0.7%	-0.3%	-0.4%	
Casualties		n.a.	n.a.	n.a.	
Tyne and Wear		**1983**	**1986**	**1992**	**Before: 1980**
Fatalities	=	0	0	0	Light rail
Injured persons	=	0	0	0	
Casualties	=	0	0	0	

Valencia		**1996**	**1999**		**Before: 1991**
Fatalities	=	0	0	n.a.	Light rail
Injured persons	=	0	0	n.a.	
Casualties	=	0	0	n.a.	

Vienna				**2002**	**Before: 1991**
Fatalities	-	n.a.	n.a.	-0.3%	Metro line
Injured persons	-	n.a.	n.a.	-0.3%	
Casualties	-	n.a.	n.a.	-0.3%	
Zurich					**No data**

Table 7-2: Synthesis table of safety indicators for the whole conurbation (annualised variations)

8 CONCLUSIONS

Nearly all the case studies within ***TranSEcon*** are public transport projects except for Delft case study which is a bicycle project. However beyond this common aspect there is great variety.

These public transport projects include rather heavy systems going from light rail (a third of the case studies: Bratislava, Manchester, Tyne and Wear, Valencia) to underground or S-Bahn type (the other two third: Athens, Brussels, Helsinki, Lyon, Madrid, Stuttgart, Vienna, Zurich). Some projects are accompanied by reorganisation of the public transport network (Athens, Bratislava, Helsinki, Lyon, Madrid) while the others are accompanied by specific parking policies such as park and ride or parking restrictions (Stuttgart, Tyne and Wear, Vienna, Zurich). Some of these transport projects are also integrated in a more global project of urban regeneration (Bratislava, Valencia, Vienna).

As regards the spatial aspects the size of the conurbation is very different from a small city like Delft (100.000 inhabitants) to a big conurbation like Madrid: most of the case studies concern medium conurbation (Bratislava, Helsinki, Lyon, Stuttgart, Tyne and Wear, Valencia, Vienna, Zurich, 0.5 to 1.5 million inhabitants) while others are large conurbations (Athens, Manchester, Brussels, Madrid, 2 to 5 millions inhabitants.)

However the length of public transport infrastructure studied here are not always correlated to the size of the conurbation: the longest ones are for Tyne and Wear (55 km) and Manchester (31 km) and the smallest ones for Bratislava (2 + 6 km) and Madrid (7 km). This combined with the size of conurbations explains partly why the effects on transport supply and demand are so different between case studies.

About half of these transport projects are located in the centre of the conurbation while the others deal with connection within suburbs or between suburbs and the centre.

All the project except Bratislava and Zurich have adopted a do-minimum scenario i.e. a scenario where the investment would not have been built and all other elements of the transport policy (both for public and private transport and parking) would have remained identical. Where a model was available data have been estimated from modelling exercises (Brussels, Madrid, Manchester, Stuttgart and Vienna). In other case studies data resulted from analysis of the evolution of some indicators of the conurbation combined with the comparison of the evolution of the same indicators in other area. Due to the variety of data sources used some caution is required when drawing conclusions from the data analysis.

Even if the investment is quite important for some conurbations, the increase in public transport supply expressed in number of places*kilometre is quite limited when compared with the supply at the level of the whole conurbation (Z1+Z2) except for the case of Tyne and Wear. The projects can be classified by their level of supply increase:

- low progression: Bratislava, Brussels, Madrid, Valencia and Vienna;

- medium progression: Helsinki, Lyon and Manchester;
- High progression: Tyne and Wear.

Since in most case studies public transport is fully integrated at the level of the conurbation or deregulated as in UK, data on financial consequences specific to these projects are scarce. When available they show no significant variation at the level of the conurbation. However at the level of the project (Helsinki, Madrid and Vienna) they show a positive effect: revenue increases far more than the costs, yielding a reduction of public transport deficit and even an increase of benefice in case of Madrid, but limited to the project catchment area.

The reference scenarii for all the conurbations have assumed an unchanged policy for private transport (road infrastructure, traffic calming and parking policy). However the impact of new supply in public transport may change the car travel conditions by indirectly improving car speed: this is the case in Athens, Lyon and Vienna, which are underground projects, while for the other projects there is no significant increase. This would mean that underground project may have a favourable impact on car speed. However this conclusion should be considered cautiously here and must be confirmed by taking into account other accompanying measures which may affect car travel. Anyway this conclusion might be explained simply by the fact that there is no suppression of road capacity per se when an underground is built and that modal shift from car to public transport reduces car traffic at least in short term.

The data analysis in this workpackage is meant to evaluate the impact of public transport project on mobility behaviour, measured by “hard data” such as public transport and car trips, distance travelled, modal share, travel times, accidents and emissions. As such they provide only a partial view of the socio-economic impacts of these projects, which will be complemented by other ***TranSEcon*** workpackages.

First of all it appears that the annualised effects on mobility behaviour are for the most part very low. This has to do with the geographical scales at which these effects are measured: these geographical scales vary widely between case studies.

However it can be said that the effects on public transport mobility are positive, and significant when related with the scope of the project. Medium sized projects such as light rails or metros of a few kilometres length have an important impact on public transport mobility in the vicinity of the project. Larger scale projects like suburban light rail of more than a few ten kilometres length have in addition a significant impact on this mobility at the whole conurbation level.

The effects on time savings are very low, for the same reasons quoted above for mobility indicators. However there is a consistent decrease of travel time on public transport network (or bicycle network for Delft): this decrease annualised effect is significant even important at the level of the project for Athens, Lyon, Madrid, Manchester, and Vienna; it is significant at the level of the whole conurbation for Stuttgart and Tyne and Wear.

Generally speaking the impact on car use is generally very low or insignificant. Travel times by car on the road network are unchanged and car mobility also.

As regard atmospheric emissions, in the case studies where data are available the environmental impact of transport infrastructure is positive or null. In all case studies this reduction of effluent emissions is related to a decrease in car use. However these impacts are very low and quite insignificant, except for Bratislava, Helsinki and Vienna where an important decrease of emission for all effluents is observed.

For accidents data are available for nine case studies only and there is no effect on accidents for four of them. Again, the variations are very small and probably not significant. From these results, it is difficult to learn a lot about the safety benefits of the projects studied here and to make definitive conclusions. The nature of the investment cannot explain a more positive impact than another investment. Accompanying measures can be as important as the infrastructure itself.

It looks as if for all case studies the conditions of travel have been improved for public transport (or bicycle in Delft) with no degradation (and perhaps improvement) for road travel time by car. This can be explained by the fact that all these projects are underground rail or transformation of existing heavy rail lines into light rail. For all these projects there is no explicit shrinkage of road capacity available for cars. Public transport mobility is improved and since car mobility is unchanged, the whole mobility increases and negative effects or car traffic are unchanged or only slightly reduced.

9 BIBLIOGRAPHY AND REFERENCES

Adviesgroep voor verkeer en vervoer (1994), Evaluatie Fietsroutenetwerk Delft, thema verkeersveiligheid, AGV, Nieuwegein

Arl, A. (1996): Methodische Ansaetze kleinraeumiger differenzierender Bevoelkerungsfortrechnung, Akademie fuer Raumforschung und Landesplanung, Hannover

Biehl, D. 1991: *The Role of Infrastructure in Regional Development,* in Vickerman, R. W. (Ed.) *Infrastructure and Regional Development*, European Research in Regional Science, 1, Pion, London, 9-35

Bovy, P.H.L. & D.N. den Adel, (1987) Mobiliteit in Middelgrote Steden, OSPA, Delft

Bovy, P.H.L. & M.J.P.F. Gommers, (1988), Verkeersonveiligheid, Voor- en Nastudie

Centraal Bureau voor de Statistiek, databestanden Onderzoek Verplaatsingsgedrag, jaren 1979 tot en met 1995

Cornelius, I. 1996: *Bevoelkerungsbilanz und natuerliche Bevoelkerungsentwicklung*, in: Statistisches Landesamt Baden-Wuerttemberg (Hrsg.): Baden-Wuerttemberg in Wort und Zahl, Statistische Monatshefte, 44/9 (Stuttgart)

EUROSIL 1999: European Strategic Intermodal Links, Project funded by DG VII, within the 4th Framework Programme

Goebel, G. 1997: *Untersuchungen ueber die Wechselwirkungen zwischen Siedlungsstruktur und Verkehrssystem am Beispiel des Ausbaus der A81 im Korridor Stuttgart – Herrenberg,* Thesis, Trier

Goodchild, M., Anselin, L., Deichmann, U. 1993: *A Framework for the Spatial Interpolation of Socioeconomic Data,* Environment and Planning A, 25, 383-397

Haag G., Gruetzmann, K. 2001: *Transport and Urban Development,* in Clark, G., Madden, M. 2001: *Regional Science in Business*, to be published

Haag, G. 1989: *Dynamic Decision theory: Application to Urban and Regional Topics* (Dordrecht, Kluwer Academic Publishers)

Haag, G., Binder, J. 2001a: *Modellgestuetzte Analyse zur regionalen Entwicklung von Beschaeftigungsvolumen, Lohnsummen und Beitragseinnahmen,* Studie im Auftrag des Instituts fuer Arbeitsmarkt- und Berufsforschung der Bundesanstalt fuer Arbeit, Nuernberg

Haag, G., Binder, J. 2001b: *Vergleichende Untersuchung der Wirkungszusammenhaenge zwischen Pendelverkehr und der raeumlichen Organisationsstruktur der*

Region Stuttgart und der Provinz Turin, Studie im Auftrag der Region Stuttgart (to be published)

Haag, G., Dendrinos, D., S. 1983: *Toward a Stochastic Dynamical Theory of Location: A Nonlinear Migration Process*, Geographical Analysis, 15, 269-286

Haag, G., Gruetzmann, K. 1997: in Landeshauptstadt Stuttgart 1997 (Hrsg.): *Modellgestuetzte Analyse und Prognose der Stadt Stuttgart*, Studie im Auftrag des Statistischen Amtes der Landeshauptstadt Stuttgart, Stuttgart

Haag, G., Gruetzmann, K. 2000: in Analyse und Prognose der kleinraeumigen Bevoelkerungsentwicklung der Stadt Stuttgart, Studie im Auftrag des Statistischen Amtes der Landeshauptstadt Stuttgart, Stuttgart

Helbrecht, I. 1996: *Die Wiederkehr der Innenstaedte. Zur Rolle von Kultur, Kapital und Konsum in der Gentrification,* Geographische Zeitschrift, 84, 1-15

IASON (2001), Deliverable 1, project assessment base line, ASON-project consortium, Delft.

IHK 1991*: Stuttgart im Standortwettbewerb, Acht Staedte und Regionen im Vergleich*, Industrie- und Handelskammer der Region Stuttgart

Katteler, H., E. Erl, O. Förg & W. Brög, J. Kropman, (1987) Vervoermiddelgebruik en Keuzebeperkingen, Eindrapport, ITS, Nijmegen.

Katteler, H., O. Förg & W. Brög, (1984),Verplaatsingsgedrag, Vooronderzoek, ITS, Nijmegen.

Ministry of Transport and Public Works, Transportation and Traffic Engineering Division, (1986) Summary Report of the Before Study, Den Haag.

Ministry of Transport and Public Works, Transportation and Traffic Engineering Division, (1987), Final Summary Report

Muconsult, Lange termijn effecten Fietsroutenetwerk Delft,(1993), Mobiliteitseffecten: Samenvatting, Utrecht.

Muconsult, Lange termijneffecten Fietsroutenetwerk Delft (1993), Analyse huis-enquête, Amersfoort, 1993

Muconsult, Lange termijneffecten Fietsroutenetwerk Delft, (1993), Analyse Verplaatsingsgegevens, Amersfoort.

Plassard, F. 1996: *Infrastructure-Induced Mobility*, European Conference of Ministers of Transport, Round Table 105, OECD, Paris

Schuermann, C., Spiekermann, K., Wegener, M. 1997: Accessibility Indicators*,* Universitaet Dortmund, Berichte aus dem Institut fuer Raumplanung (IRPUD), 39, Dortmund

SNV 1990: *Vereinfachte Nachfrageermittlung und Kosten-Nutzen-Abschaetzung fuer Park-and-Ride-Anlagen,* Teil 1: Nachfrageermittlung, in: Verkehr und Technik, Heft 3, 1990

SOBEMAP (1983) Updating the patronage forecast for several variants of the network of public transport service routes of the Brussels conurbation *(Mise à jour des prévisions des flux de voyageurs sur différentes variants du tracé du réseau des lignes de transport en commun de l'agglomération bruxelloise)*, for the Ministry of Communications

SSP 1997: *Vergleichende Bewertung unterschiedlicher P&R-Konzepte,* Studie im Auftrag des Bundesministeriums fuer Verkehr, FE-Nr. 77385/94, Stuttgart 1997

SSP, STASA 1999: *Auswirkungen von telematischer Beeinflussung verkehrsinfrastruktureller Kapazitaeten auf die volkswirtschaftliche Rentabilitaet von Projekten der Bundesverkehrswegeplanung*, Studie im Auftrag des Bundesministeriums fuer Verkehr, FE-Nr. 96481/1997

STASA 1996: *Qualifizierung, Quantifizierung und Evaluierung wegebauinduzierter Befoerderungsprozesse*, Studie im Auftrag des Bundesministeriums fuer Verkehr, FE-Nr. 90436/1995

STASA 1999: *Modellierung agglomerationsbedingter Einfluesse auf wegebauinduzierte Befoerderungsprozesse fuer die Bundesverkehrswegeplanung,* FE-Nr. 90546/1998

Statistisches Jahrbuch Stuttgart 2000, Statistisches Amt der Landeshauptstadt Stuttgart

Stier, W. 2001: *Methoden der Zeitreihenanalyse,* Springer (Berlin, Heidelberg, New York)

STRATEC (1993) Urban mobility master plan of the Brussels – Capital Region (IRIS Plan) (Plan des déplacements urbains de la Région de Bruxelles – Capitale), for the Brussels-Capital Regional Authority

STRATEC (1998) Environmental impacts assessment for the extension of the Inner Ring metro line between "CLEMENCEAU" et "BEEKKANT" stations *(Etude d'incidences de l'extension de la ligne métro "PETITE CEINTURE" entre les stations "CLEMENCEAU" et "BEEKKANT")*, for the Brussels – Capital Regional Authority

STRATEC (in progress) Updating and adapting the Urban Mobility Master Plan of the Brussels-capital Region (IRIS Plan) *(Mise à jour et adaptation du Plan des déplacements urbains de la Région de Bruxelles – Capitale Plan IRIS)*, for the Brussels – Capital Regional Authority

Straubhaar, Th. 1988: *On the Economics of International Labor Migration*, Beitraege zur Wirtschaftspolitik, Bd. 49 (Haupt, Bern, Stuttgart)

***TranSEcon* (2002a),** Deliverable 1, State of the art, BOKU, Vienna 2001

***TranSEcon* (2002b),** Deliverable 2, Common analytical framework, BOKU, Vienna 2001

Wegener, M. 1999: *Modelling Accessibility,* in WP7 of EUROSIL 1999: European Strategic Intermodal Links, Project funded by DG VII, within the 4th Framework Programme

10 ABBREVIATIONS

Abbreviation	Description
Before	Scenario before
CBD	Central Business District
Inhab.	Inhabitant
n.a.	Data non available
Project	The public transport investment to be assessed
PT	Public Transport
RS	Reference scenario
TranSEcon	Urban Transport and local Socio-Economic Development
With	Scenario with
Zproject	Zone of the project (see section 3.1.2)
Z1	Zone directed impacted by the project (see section 3.1.2)
Z2 (Z2a, Z2b)	Zone concerned by the project (see section 3.1.2)
Z3	Control area zone not concerned by the project (see section 3.1.2)